Centennial Hunter Pty Limited

ANVIL HILL PROJECT

environmental assessment

VOLUME 4 - APPENDIX 9a

Umwelt
Environmental Consultants

AUGUST 2006

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Centennial Hunter Pty Limited

Ecological Assessment
Anvil Hill Project

June 2006

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1.0 Introduction

1.1 Project Description

1.1.1 Background to the Anvil Hill Project

Centennial Hunter Pty Limited (Centennial) proposes to establish an open cut coal mine and ancillary facilities including a Coal Preparation Plant (CPP) and rail loop in the Wybong area, 20 kilometres west of Muswellbrook and approximately 10 kilometres north of the township of Denman (**Figure 1.1**). The proposal, known as the Anvil Hill Project (the Project), is based on a large, undeveloped coal reserve of approximately 150 million tonnes (Mt) that is suitable for production of thermal coal for both domestic and export markets.

The Project is a 'major project' development which requires the approval of the NSW Minister for Planning. An Environmental Assessment (EA) will be prepared for the proposal to mine up to 10.5 million tonnes per annum (Mtpa) using truck and shovel methods. Approval will be sought for a 21 year project life, concurrent with the duration of a mining lease to be sought for the operation. If approved, Centennial is targeting commercial production by early 2008, and it is expected the Project could provide ongoing employment for up to 250 people.

1.1.2 The Study Area

The project application area (the Project Area) comprises 3763 hectares with approximately 2238 hectares of this area proposed to be disturbed by the Project. Definitions of key boundaries used in this report are:

- **Proposed Disturbance Area –** represents the proposed footprint for the Project. All land within this boundary may be directly impacted or disturbed in some way due to activities associated with the operations, such as mining, infrastructure or construction, at some time during the 21 year approval period which is to be sought.

- **Proposed Offset Areas –** refers to land that may be potentially available as biodiversity offsets for the Project. The final area potentially available for offsets is yet to be confirmed, however areas presently likely to be available have been subject to a similar level of ecological survey as the Proposed Disturbance Area.

- **Study Area –** includes the Proposed Disturbance Area and additional land that has the potential to be included in an offsets area (Proposed Offset Areas). The land within the Study Area is (or is expected to be) under the control of Centennial. The total area of the Study Area is 4142 hectares.

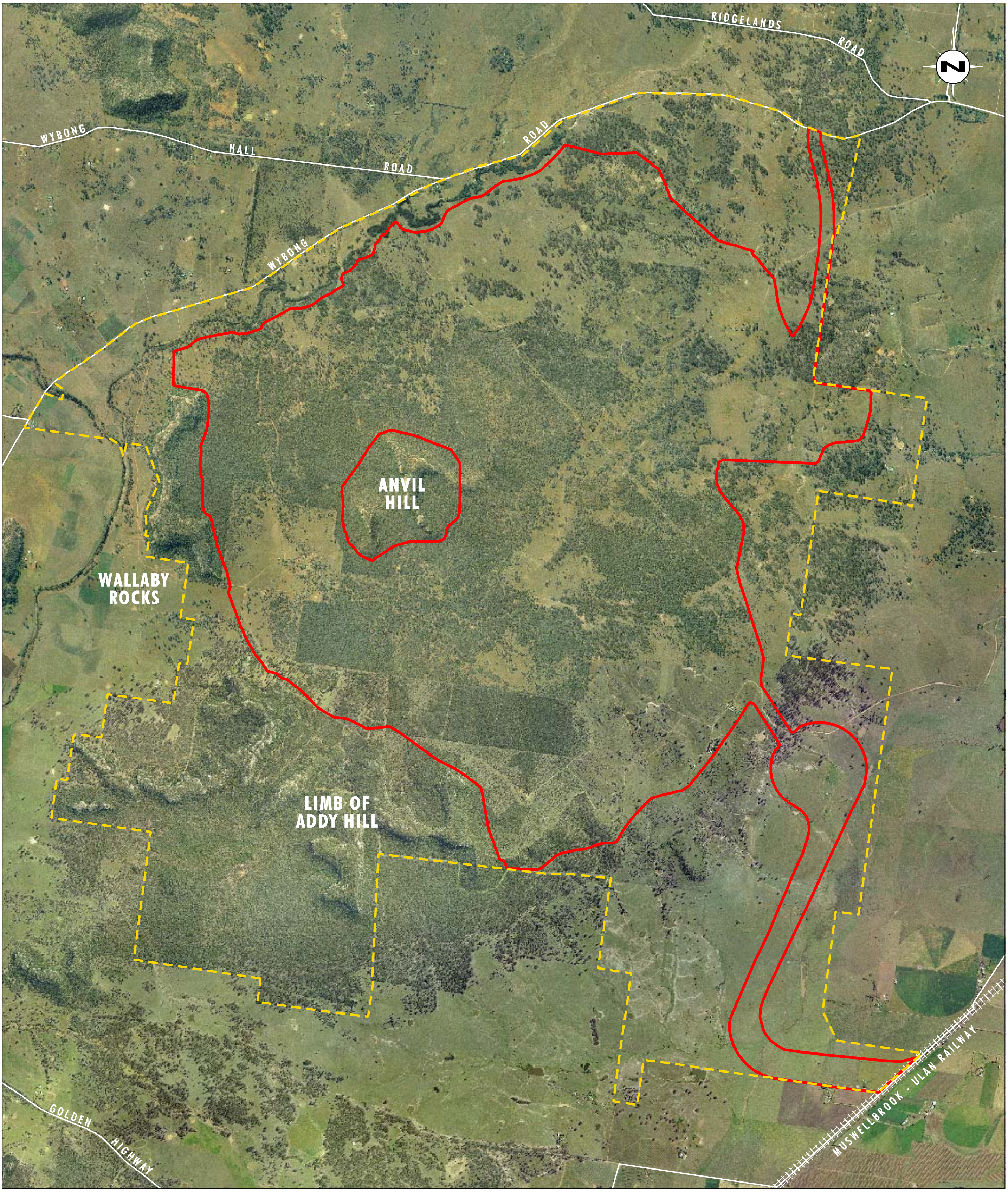
The general locality of the Project is recognised as containing a large area of native vegetation. For this reason, detailed flora and fauna surveys have been conducted by Umwelt (Australia) Pty Limited (Umwelt) ecologists over the past two years. The survey strategy utilised at the site has been developed in consultation with the NSW Department of Environment and Conservation (DEC) and Department of Planning (DoP). These surveys covered the entire Study Area and included both the Proposed Disturbance Area and Proposed Offset Areas (**Figure 1.2**).

1.1.3 Environmental Setting

The Project area is located in the Upper Hunter Valley, on the margin of the valley floor. The Project area has been extensively used for agriculture since the 1800s and is dominated by undulating grazing land with remnant and regrowth woodland. The locality immediately surrounding the Project area consists of mostly smaller rural holdings, dominated by rural

FIGURE 1.1

Locality Plan



Base Map: Dept. of Lands (2003), ortho-rectified by Plateau Images

0 0.5 1.0 2km

Legend

Proposed Disturbance Area
Study Area

FIGURE 1.2

Project Area and Surrounds

residential land use and cattle grazing, but also includes more intensive agricultural land uses such as vineyards, irrigation for lucerne and dairies.

The topography of the Proposed Disturbance Area varies from lower slopes towards the Hunter River, through undulating and hilly lands to rocky outcrops. A notable topographical feature within this area is Anvil Hill itself which rises approximately 70 metres above the surrounding area at its highest point. It is located at the centre of the Proposed Disturbance Area and consists of two hills connected by a saddle. Anvil Hill is not proposed to be mined. The lower areas of the Proposed Disturbance Area are currently used for pastoral grazing and a 500 kV TransGrid powerline crosses the Study Area in a south-east/north-west direction.

The topography of the area surrounding the Proposed Disturbance Area is dominated by a row of hills to the west and south. The hills to the west are not officially named, although they are known locally as “Wallaby Rocks”. Wallaby Rocks rise to a height of 264 metres Australian Height Datum (mAHD), being approximately 100 metres above the surrounding area, and contain a visually dominant escarpment along the western side. The rocky area to the south known as Limb of Addy Hill rises to a height of 302 mAHD, which is also approximately 100 metres above the surrounding area.

The Project is located within the catchments of Anvil Creek, Clarks Gully, Big Flat Creek and Sandy Creek. Both Anvil Creek and Clarks Gully flow into Big Flat Creek. Big Flat Creek flows into Wybong Creek which is a tributary of the Goulburn River. The Goulburn River joins the Hunter River approximately 4.8 kilometres downstream from Denman. Sandy Creek drains to the Hunter River at Denman.

1.1.4 Description of Project

The conceptual mine layout is shown on **Figure 1.3**. In overview, the Project comprises the design, construction and operation of:

- an open cut coal mine;
- coal handling, crushing and stockpiling facilities and a coal preparation plant (washery);
- water management, supply and distribution infrastructure;
- handling and placement of overburden (rock);
- mine access road including a new intersection on Wybong Road, internal access roads and haul roads;
- infrastructure including offices, staff amenities, workshop, conveyors, and ancillary services; and
- a rail spur, rail loop and rail loading infrastructure for the transport of all product coal.

Detailed mine and project planning has been undertaken to develop a Conceptual Mine Plan, with indicative stages modelled at Years 2, 5, 10, 15 and 20.

To achieve consistent coal quality, scheduling has allowed for concurrent operation of four pits for most of the mine life. The proposed mining method will provide for an efficient operation in which environmental impacts can be minimised.

Rehabilitation will be scheduled to commence as soon as possible after mining disturbance, to minimise the disturbed area at any point in time.

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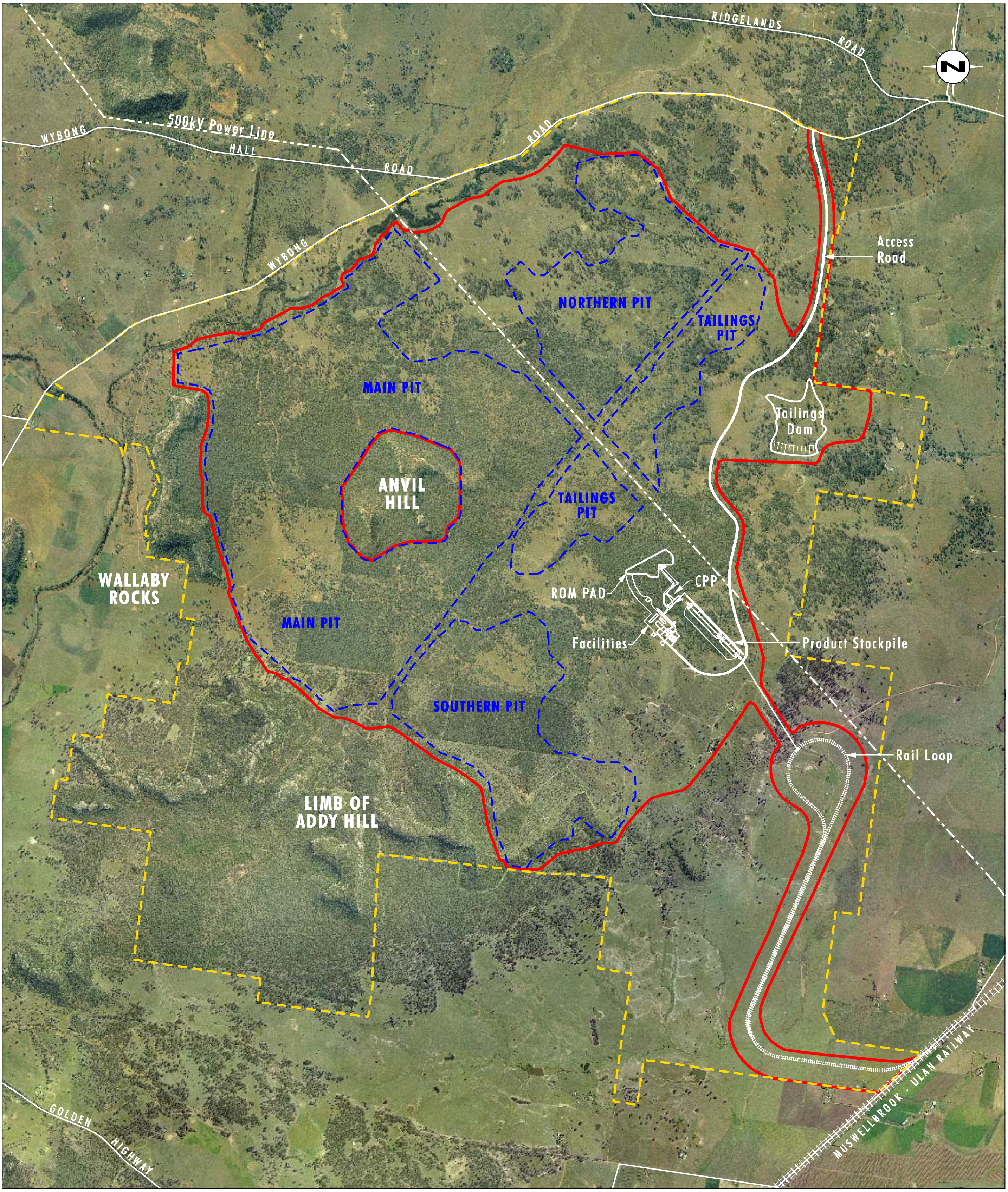


Source: Mine Consult (2005)
Base Map: Dept. of Lands (2003), ortho-rectified by Plateau Images

0 0.5 1.0 2km

Legend

- Proposed Disturbance Area
- Study Area
- Proposed Mining Area

FIGURE 1.3

Conceptual Mine Layout

File Name (A4): R01_V1/1858_333.dgn

The proposed final land use will include self sustaining indigenous vegetation communities, consisting of native and naturalised tree, shrub and grass species.

1.2 Purpose of this Document

This ecological assessment has been prepared by Umwelt to provide information about the potential impact of the Project on native flora and fauna species, populations and ecological communities occurring in the Study Area. Terrestrial vegetation communities, flora and fauna species and fauna habitat present in the Study Area have been identified and considered, as have the aquatic flora and fauna features. The assessment addresses potential impacts on any threatened species, endangered population, endangered ecological community, or their habitat that may occur in, or in the general vicinity of, the Study Area.

The objectives of the ecological assessment were to:

- record the flora and fauna (both terrestrial and aquatic) within the Study Area;
- identify any threatened flora and fauna, endangered populations, endangered ecological communities, or their habitats, particularly those listed under the *Threatened Species Conservation [TSC] Act* 1995 (NSW) and the *Environment Protection and Biodiversity Conservation [EPBC] Act* 1999 (Commonwealth) and *Fisheries Management [FM] Act* 1994;
- assess the impact that the Project would have on any threatened flora and fauna, endangered populations, endangered ecological communities, or their habitats recorded in the Study Area;
- provide management options to minimise ecological impacts associated with the Project, including modifications to the design or operation of the Project, and other on-site impact mitigation; and
- assess the value of potential areas available to offset residual ecological impacts and provide management options for a biodiversity offset strategy; and
- assess the performance of the Project against the overall goal of no net loss of flora and fauna values in the area in the medium to long term. In this case, medium term is defined as beginning at the end of the life of the mine, that being Year 21.

2.0 Regional Setting

2.1 Physiography

The Study Area is situated at the western extremity of the main floor of the Hunter Valley. It lies centrally within the 22,000 km^2 Hunter catchment, which is largely drained by the Hunter and Goulburn rivers and their tributaries. It is situated approximately 120 kilometres from the coast and 90 kilometres from the western extremity of the Hunter catchment at the Great Dividing Range.

The Study Area is essentially a disjunct eastern occurrence of the dissected Triassic sandstone and conglomerate plateau that forms the Goulburn River complex to the west. To the south is the more extensive dissected sandstone plateau of the Wollemi Wilderness, while to the north a more eroded Triassic sandstone and conglomerate complex has formed low hills and escarpments in the Moobi district to the west of Aberdeen. To the east of the Study Area and extending north-north-east to Scone and east-south-east to Maitland are the highly eroded Permian lowlands of the floor of the Hunter Valley. The Study Area itself supports both low Permian hills and valleys, and Triassic conglomerate outcrops and escarpments. An extensive area of Tertiary basalt flow occurs on the Merriwa Plateau, which lies approximately 20 kilometres to the north-west of the Study Area.

2.2 Catchment Characteristics

The Study Area is located within the catchments of Anvil Creek, Clarks Gully, Big Flat Creek and Sandy Creek. Both Anvil Creek and Clarks Gully flow into Big Flat Creek in the north-west of the Study Area. Big Flat Creek flows into Wybong Creek which is a tributary of the Goulburn River. The Goulburn River joins the Hunter River approximately 4.8 kilometres downstream of Denman. Sandy Creek drains to the Hunter River at Denman.

The Hunter River originates in the Mount Royal Range and Barrington Tops plateau, flowing for some 250 kilometres to the sea at Newcastle. River regulation has lead to the disruption of natural flow regimes and stream geomorphological impacts. In addition, land clearing over the past 200 years has lead to the degradation of riparian corridors, broad scale hydrological changes, biodiversity losses, stream bank erosion and sedimentation.

The Hunter River Inquiry (Healthy Rivers Commission 2002) provided evidence that ecological sustainability is not currently being achieved in the Hunter catchment. Across the catchment, only one third of streams are in good condition, with stable banks and a natural pool / riffle structure, and approximately 10% of streams are unstable. Water quality is extremely variable and the extraction of water has placed most streams under stress. Studies of macroinvertebrates show that between 40% and 70% of sites or subcatchments surveyed are in poor condition and approximately 30% of native fish species have been lost from the catchment.

Wybong Creek is a tributary of the Goulburn River, extending some 90 kilometres from its headwaters in the Liverpool Ranges in the north, to its confluence with the Goulburn River in the south. The catchment of Wybong Creek covers an area of approximately 67,369 hectares at its confluence with Big Flat Creek, and a total catchment area of approximately 80,044 hectares at its confluence with the Goulburn River. Land use within the catchment downstream of the confluence of Wybong Creek and Big Flat Creek includes grazing land and some forested areas in the vicinity of Limb of Addy Hill in the south-east.

Surface water quality is discussed in the main text of the EA. The results showed the variability of water quality in the local creeks. Big Flat Creek, for example, just north of the

Proposed Disturbance Area, has high salinity (570 µS/cm to 50,500 µS/cm) and flows into Wybong Creek. Wybong Creek generally has lower salinity (490 µS/cm to 3610 µS/cm), upstream and downstream of the Study Area.

2.3 Vegetation Types and Plant Species

The areas surrounding the Study Area are predominantly composed of two broad vegetation types: rugged escarpment woodlands and heaths; and valley floor woodlands and derived pastures.

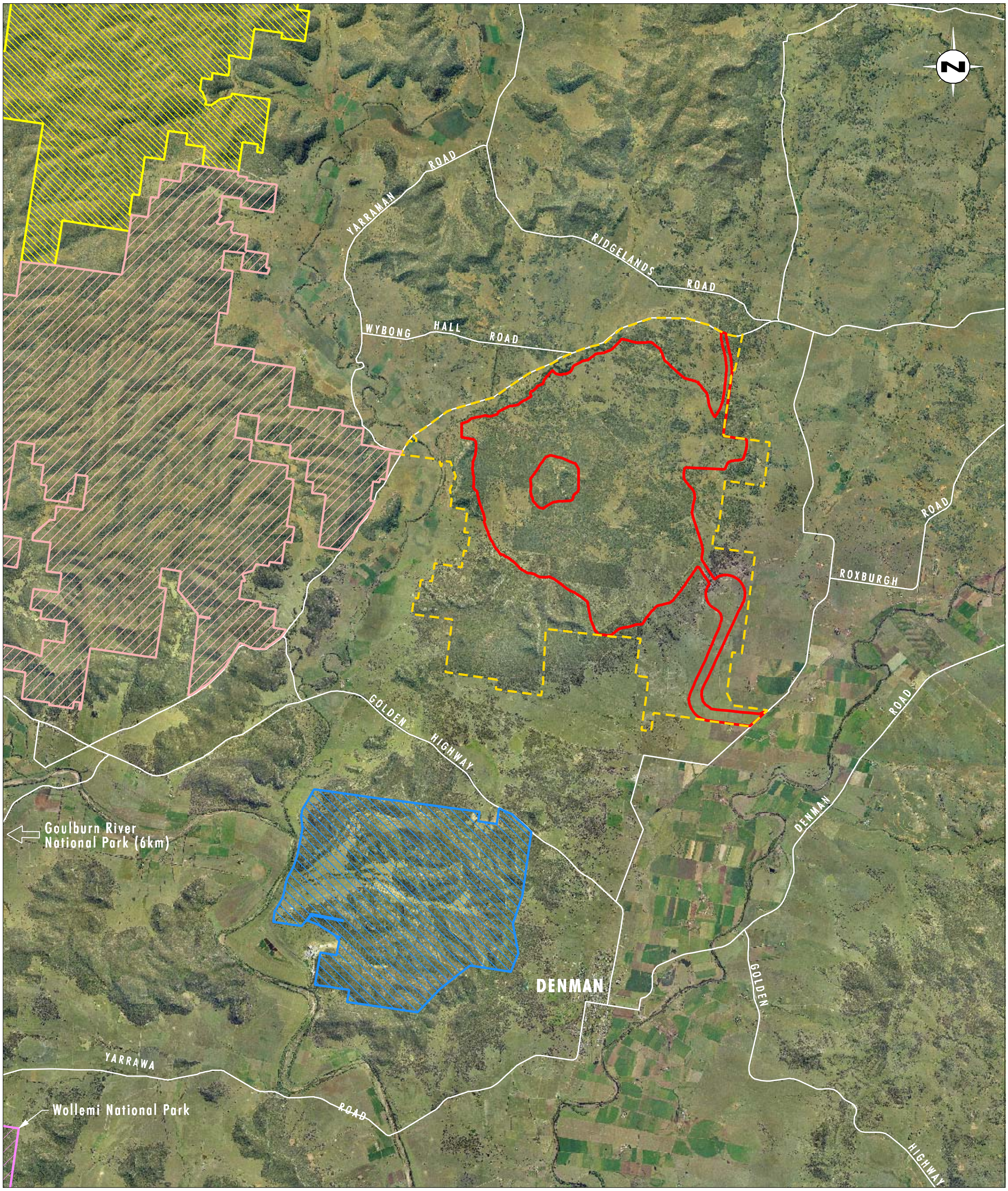
Most of the nearby dissected sandstone and conglomerate areas have been studied through a variety of vegetation survey and mapping projects. Wollemi National Park occupies approximately 500,000 hectares to the south of Denman (**Figure 2.1**). It was surveyed by Bell (1998), who mapped 72 vegetation communities and recorded over 1360 plant species, of which 70 were considered to be rare or threatened. Some vegetation communities within the Study Area are similar to those recorded on the north-eastern boundary of Wollemi National Park.

To the north of Wollemi National Park, and closer to the Study Area, lies Myambat Military Area (**Figure 2.1**). This area covers approximately 1800 hectares of natural bushland approximately three kilometres west of Denman. Fallding et al (1999) surveyed and mapped ten native vegetation communities in the Myambat Military Area, ranging from alluvial forest to rocky heath and sclerophyllous open forests and woodlands, with small areas of dry rainforest in sheltered sites. The survey recorded 391 native plant species, including six rare or threatened Australian plants (ROTAPs), four of which were also listed as threatened under the TSC Act 1995. Several vegetation types recorded in Myambat Military Area are closely related to vegetation communities that occur in the Anvil Hill Study Area.

Manobalai Nature Reserve and vacant Crown land (VCL), which are approximately ten kilometres to the north-west and two kilometres to the west of the Study Area respectively (**Figure 2.1**), also support several vegetation types that are closely related to those in the Study Area. Peake (1999) mapped the 3759 hectare Manobalai Nature Reserve, and Bell (1997) mapped the 4500 hectare VCL. Peake (1999) and Bell (1997) recorded 15 vegetation communities between the two areas, ranging from dry sclerophyll sandstone forests and heaths, to alluvial forests, basalt-derived woodland and dry rainforest. Bell recorded a total of 246 plant species in Manobalai VCL, including three ROTAPs, one threatened species listed under the TSC Act 1995 and two undescribed species, while Peake recorded 352 plant species in Manobalai Nature Reserve.

Similar vegetation types also occur in Goulburn River National Park, to the immediate west of Manobalai VCL (**Figure 2.1**). Goulburn River National Park covers approximately 71,000 hectares stretching roughly 60 kilometres east from Ulan to Sandy Hollow. The eastern boundary of the reserve is approximately 15 kilometres west of the Anvil Hill Study Area and supports several vegetation units similar to those in the Study Area. Hill (1999 and 2000) surveyed and mapped vegetation in Goulburn River National Park, as well as the nearby Munghorn Gap Nature Reserve, and described 27 vegetation communities and 630 plant species, including 23 ROTAPs and 14 species listed under the TSC Act 1995.

Permian-derived vegetation communities in the Study Area are also closely related to many of the vegetation types surveyed, mapped and described by Peake (2006) for the floor of the central Hunter Valley. The Peake (2006) study was conducted on behalf of the Hunter-Central Rivers Catchment Management Authority (HCRCMA) and is referred to as the Hunter Remnant Vegetation Project. That study area covered 315,000 hectares stretching from Scone in the north to Denman in the south-west and Branxton in the south-east. As shown on **Figure 2.2**, the study area wholly included the Anvil Hill Study Area. This work



Source: Peake (2006)
Base Map: Dept. of Lands (2003), ortho-rectified by Plateau Images

0 1 2.5 5km

Legend

- Proposed Disturbance Area
- Study Area
- Myambat Military Area
- Manobalai Nature Reserve
- Bell (1997) Manobalai Study Area

FIGURE 2.1

Regional Area and Existing Conservation Areas

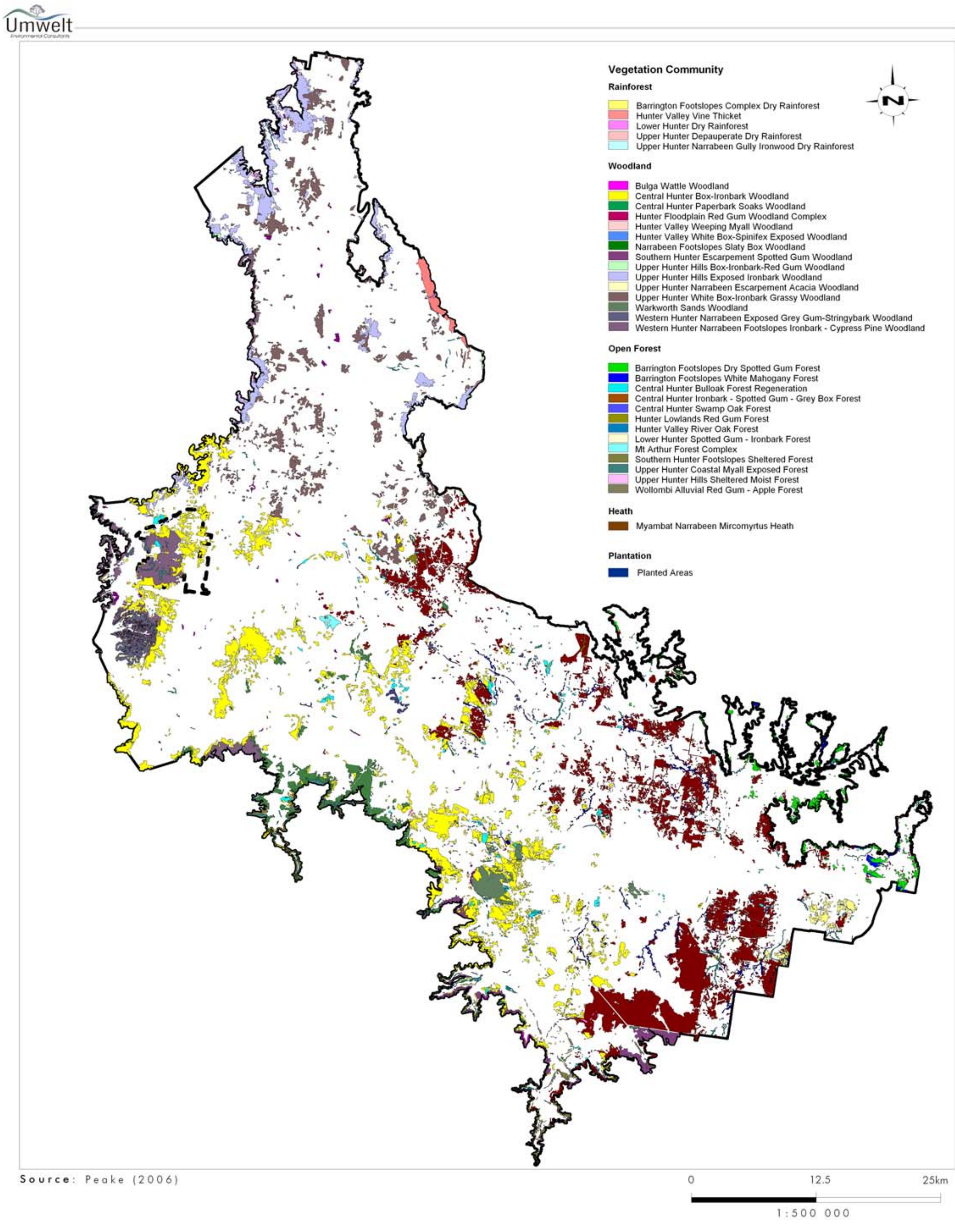


FIGURE 2.2

Hunter Remnant Vegetation Project Study Area included the botanical survey of 327 sites and mapping of approximately 60,000 hectares of forest or woodland remnants. Peake (2006) found that the native forests and woodlands of the central Hunter Valley have probably been reduced by approximately 76% (238,000 hectares) since Europeans arrived in Australia.

Most remaining forest remnants on the Hunter Valley floor are small, with 87% being less than 10 hectares in size, and the median remnant size being 1.6 hectares (Peake 2006). Approximately 65% of all remnant vegetation on the Hunter Valley floor occurs within a few remnants that are over 100 hectares in area, with the largest remnant, which is mostly within Myambat Military Area near Denman, being approximately 2250 hectares. The second-largest remnant mapped was that at Wybong Uplands (which includes the Anvil Hill Study Area), covering 2067 hectares.

Thirty-six vegetation communities were delineated by Peake (2006) in the central Hunter Valley, comprising five rainforest communities, 16 woodlands, 13 open forest communities, one heath and one (unnatural) plantation community. Nine of these occur in the Anvil Hill Study Area. Five are listed as endangered ecological communities (EECs) under the TSC Act 1995, while a further community has been nominated for listing. Twenty-two of the 36 identified communities meet the criteria for listing as EECs under the TSC Act 1995 or the Commonwealth EPBC Act 1999 and the remaining 13 naturally-occurring vegetation communities are either restricted or limited in extent (Peake 2006). Only a small number of vegetation communities described by Peake (2006) are well-represented in the NSW conservation reserve system. Most have relatively poor representation and a few communities, that are generally restricted to the valley floor, have little or no representation in existing reserves (Peake 2006).

Peake (2006) recorded 1127 plant species in the remnant vegetation of the central Hunter Valley, 22% of which were not native to the area. Twenty-five plant species are of significance (either ROTAPs or listed under the TSC Act 1995 or EPBC Act 1999). Peake (2006) also recorded two previously undescribed species, 31 range extensions and seven species endemic to the Hunter Valley. Thirty-seven plant species occurring on the Hunter Valley floor are regionally rare and twelve plant populations are regionally endangered (Peake 2006). Of these populations, three are listed under the TSC Act 1995. Peake (2006) also recorded twenty noxious or nationally significant weed species, and 49 important environmental weeds. A number of these significant plant species and weeds, and two plant populations occur within the Anvil Hill Study Area, as described in **Section 4**.

2.4 Fauna Habitats and Species

The broad fauna habitat types of grassland, riparian, woodland, aquatic and escarpment habitat found within the Study Area are representative of the broad habitat types within the surrounding region, as described in **Section 6**.

To the north-west, west and south-west surroundings of the Study Area, the landscape is dominated by areas of steep escarpment. The escarpment areas within the Study Area represent the approximate eastern limit of the escarpment landscape that is loosely associated with the escarpment country of Goulburn River National Park to the west of the Study Area, and Manobalai Nature Reserve to the north-west (see **Section 2.1**). To the north, north-east, east and south-east surroundings of the Study Area, the landscape is dominated by undulating farmland containing scattered small stands of native vegetation.

Relatively few fauna surveys or studies of fauna habitats have been undertaken in the local area. Exceptions to this include studies at Myambat Military Area (Fallding et al. 1999), south of the Study Area; Wollemi National Park (Roderick and Carter 1994) south of the Study Area; and Goulburn River National Park (NSW NPWS 2001), west of the Study Area

(**Figure 2.1**). These areas support a range of fauna habitats, the most widespread of which are the dry, sclerophyllous open forests and woodlands dominating dissected sandstone ridges and slopes. These habitats are characterised by a dry environment with little to no standing water. Habitat is provided by a moderately open canopy and a sclerophyllous understorey that ranges from very dense to sparse, while the ground cover is generally sparse. This dissected landscape provides areas of rock overhangs and crevices that are utilised by a range of species.

Alluvial forests, woodlands and grasslands provide a relatively denser vegetation cover. The relatively larger sizes of trees supported by the alluvial soils often also provide larger-sized hollows than those found on surrounding, drier slopes and ridges. The alluvial sites also provide ephemeral standing and moving water, with small wetlands and farm dams occurring in some areas. Farm dams and ephemeral creek lines and drainage lines are common across the undulating farmland surrounding the Study Area.

Fallding et al. (1999) recorded 16 threatened fauna species in the Myambat Military Area listed under the TSC Act 1995. These include several species of bats, parrots, the squirrel glider (*Petaurus norfolcensis*) and several woodland birds.

NSW NPWS (2001) recorded 23 threatened fauna species in Goulburn River National Park. These included 20 species listed under the TSC Act 1995, several of which were also listed under the EPBC Act 1999. Records included a range of woodland bird species, owls, and parrots, as well as several bat species, the squirrel glider and the brush-tailed rock-wallaby (*Petrogale penicillata*). NSW NPWS (2001) indicated that the mallee fowl (*Leipoa ocellata*) may also be present in the reserve, although this was not confirmed.

Roderick and Carter (1994) surveyed fauna over one year in the northern portion of Wollemi National Park. They recorded four species of bird that are now listed under the TSC Act 1995. No records of the brush-tailed rock-wallaby were made through this study, however scats potentially belonging to this species were collected for later expert identification. The report does not identify the results of this expert identification.

2.5 Conservation Areas

Three conservation reserves are located within 15 kilometres of the Study Area (**Figure 2.1**). The closest of these, Manobalai Nature Reserve, is situated approximately ten kilometres to the north-west and comprises rugged sandstone escarpments and small areas of residual basalt outcropping within its 3759 hectares area. Wollemi National Park, covering an area of approximately 480,000 hectares, lies just over ten kilometres south of the Study Area and extends south to the Blue Mountains, north-west of Sydney. It is the second largest conservation reserve in NSW, and protects mostly dissected sandstone plateaux, narrow gorges and extensive escarpments. Finally, Goulburn River National Park lies approximately 15 kilometres to the west of the Study Area and extends about 60 kilometres west to Ulan. It covers approximately 71,000 hectares of dissected sandstone plateaux, gorges, escarpments and minor residual basalt outcropping.

These three reserves all protect similar Triassic environments to those occurring in the Proposed Offset Areas. There are no reserves on the floor of the Hunter Valley that protect vegetation similar to that occurring on the Permian sediments in the Study Area.

The only reserve occurring on the floor of the central Hunter Valley is the 292 hectare Belford National Park that lies about 60 kilometres to the east of the Study Area.

3.0 Methods

A detailed survey methodology was designed and completed in order to gain a thorough understanding of the ecological features of the Study Area. The methods consisted of a detailed literature review, including searches of all relevant ecological databases. Information gathered from the literature reviews and database searches was then used to design an extensive field survey program to map and survey vegetation communities, and to target threatened species, endangered populations, endangered ecological communities, or their habitats, including aquatic features. A similar level of survey effort was undertaken across both the Proposed Disturbance Area and Proposed Offset Areas as part of this field program.

Following the completion of the field survey, a rigorous ecological condition assessment was conducted across the Study Area to assist in the development of a comprehensive biodiversity offsets package. This condition assessment was designed to enable the direct comparison of habitat types and overall ecological condition between the Proposed Disturbance Area and Proposed Offset Areas.

3.1 Literature Review of Previous Surveys

The literature review for the flora and fauna surveys involved the use of a number of documents, including a detailed regional vegetation assessment, site-specific surveys completed within the Study Area, and further surveys undertaken next to, or close to the Study Area. Each document is discussed in detail below, focusing on the relevant findings considered in development of the strategy for further survey and subsequent assessment.

3.1.1 Hunter Catchment Management Trust (Peake 2006)

The Vegetation of the Central Hunter Valley, New South Wales. A Report on the Findings of the Hunter Remnant Vegetation Project. Hunter – Central Rivers Catchment Management Authority, Paterson

As part of its study of remnant vegetation in the 315,000 hectare central Hunter Valley (Peake 2006; see **Section 2.3**), the Hunter Catchment Management Trust (now Hunter – Central Rivers Catchment Management Authority) sampled 13 plots and undertook extensive ground-truthing of vegetation community boundaries in the Anvil Hill Study Area between 2 September 1999 and 17 July 2001. As part of the broader survey, representative plots were sampled from broad vegetation communities to assess mapped vegetation boundaries in the locality referred to as the Wybong Uplands, which includes the Anvil Hill Study Area.

The flora sampling methods were consistent with those reported in this study, and the results have been used as part of this assessment. In total, 218 plant species, of which 19 (9%) were weeds, were recorded. Nine vegetation communities were mapped, and are described in detail in Peake (2006). These comprise the following map units:

- MU 6 - Upper Hunter Hills Exposed Ironbark Woodland;
- MU 8 - Western Hunter Narrabeen Footslopes Ironbark – Cypress Pine Woodland;
- MU 10 - Central Hunter Box – Ironbark Woodland;
- MU 11 - Upper Hunter White Box – Ironbark Grassy Woodland;
- MU 13 - Hunter Floodplain Red Gum Woodland Complex;

- MU 19 - Hunter Valley Weeping Myall Woodland;
- MU 28 - Central Hunter Swamp Oak Forest;
- MU 32 - Central Hunter Bulloak Forest Regeneration; and
- MU 33 - Upper Hunter Coast Myall Exposed Forest.

Of these, Peake (2006) regarded all but two (MU 8 - Western Hunter Narrabeen Footslopes Ironbark – Cypress Pine Woodland and MU 33 - Upper Hunter Coast Myall Exposed Forest) to be of conservation significance and under threat. Of these, three were regarded as potentially meeting the critically endangered listing criteria of DEH (2006): MU 13 - Hunter Floodplain Red Gum Woodland Complex, MU 19 - Hunter Valley Weeping Myall Woodland and MU 28 - Central Hunter Swamp Oak Forest.

No threatened flora species were recorded in the Study Area.

3.1.2 HLA Envirosciences (2002A)

Flora and Fauna Studies at Anvil Hill, Muswellbrook. Prepared for Powercoal Pty Limited

This report documents the results of a ten day flora and fauna survey period undertaken from 19 – 28 February 2002, for the purpose of describing the flora and fauna of the exploration lease 5552. This exploration lease area covers an area of approximately 3400 hectares, however access for this survey was restricted to a study area of approximately 1400 hectares.

The flora survey was designed to assist the mapping of the vegetation communities based on a dominant species/structure classification system. The flora survey was completed over six days in February 2002, and involved the use of random meanders, 100 metre transects and 20 x 20 metre quadrats. Aerial photographs were used to assist the mapping of vegetation communities.

The flora surveys resulted in the identification of 253 species, with 214 natives, and 39 exotic species. One threatened flora species, narrow goodenia (*Goodenia macbarronii*), was identified during surveys. The following vegetation communities were mapped:

- narrow-leaved ironbark woodland complex;
- narrow-leaved ironbark – black cypress pine woodland;
- dry open heath – shrubland – low woodland;
- slaty box woodland complex;
- three-awned grass grassland;
- grey gum – narrow-leaved ironbark sheltered open forest;
- tall moist red ash – native olive shrubland;
- forest red gum riparian open woodland;
- swamp oak riparian forest;

- drooping sheoak dry shrubland; and
- grey box low open woodland.

Fauna surveys were designed to identify the fauna species using the vegetation communities of the study area. Surveys were completed over a period of nine days in February 2002, and included nocturnal and diurnal surveys. Survey methods included the following standard techniques:

- spotlighting;
- nocturnal amphibian searches;
- micro-bat echolocation recording;
- call playback;
- diurnal bird survey;
- diurnal herpetofauna searches;
- cage trapping;
- terrestrial Elliot A trapping;
- arboreal Elliot B trapping;
- signs of presence (scats, hairs, scratches, prints etc); and
- opportunistic observations.

The study area was described as showing impacts from a number of disturbances, including land clearing, selective logging, earthworks, infrastructure, salinity, erosion, fire, agriculture, mining and quarrying, and exotic flora and fauna.

Fauna surveys identified a total of 109 species within the study area. This included five threatened species, namely:

- grey-crowned babbler (*Pomatostomus temporalis temporalis*);
- brown treecreeper (*Climacteris picumnus victoriae*);
- speckled warbler (*Pyrrholaemus sagittata*);
- glossy black-cockatoo (*Calyptorhynchus lathami*); and
- diamond firetail (*Stagonopleura guttata*).

There was a tentative record of the eastern false pipistrelle (*Falsistrellus tasmaniensis*), from Anabat surveys.

This report also makes reference to previous records of the hooded robin (*Melanodryas cucullata cucullata*), powerful owl (*Ninox strenua*) and painted honeyeater (*Grantiella picta*), but does not indicate the source of these records.

Finally, the report identified a number of threatened species with potential to occur on the Study Area, and recommended that further detailed surveys (particularly fauna) would be required.

3.1.3 HLA Envirosciences (2002B)

Statement of Environmental Effects – Bulk Sampling Activity, Exploration Lease 5552

This Statement of Environmental Effects (SEE) was prepared in October 2002 in order to document the potential environmental impacts of the proposed excavation of a bulk sample pit on Exploration Lease 5552. The proposal involved the excavation of approximately 35,000 tonnes of coal over a period of three to four months. Centennial resolved that the bulk sample was not necessary and therefore this work has not proceeded.

A number of specialist environmental studies were completed for this SEE, including ecological investigations.

Flora studies took place over the period including 21 March, 12 April and 16 May 2002. Fauna studies took place over 15 – 19 April 2002. HLA Envirosciences was not able to provide detailed information on all survey results from this period, but wherever the available information was adequate, it was included within the current impact assessment.

As well as field survey, HLA Envirosciences completed a literature review of previous surveys of the area to assist in the impact assessment. Searches of the NPWS Atlas of NSW Wildlife (NPWS 2002) were also used to identify previous threatened species records within a 20 kilometre radius of the HLA Envirosciences study area.

During flora surveys, the following vegetation communities were identified within the study area:

- narrow-leaved ironbark – bulloak woodland;
- slaty box woodland;
- three-awned speargrass grassland;
- forest red gum woodland; and
- swamp oak riparian forest.

This flora survey also identified two populations of the threatened species narrow goodenia (*Goodenia macbarronii*), which is listed as Vulnerable under the TSC Act 1995 and EPBC Act 1999.

During fauna surveys, the following threatened species were identified within the study area:

- speckled warbler (*Pyrrholaemus sagittata*); and
- brown treecreeper (*Climacteris picumnus*).

The SEE reports that no further threatened fauna species were recorded during this survey period. Despite this, the document contains reference to further threatened fauna species recorded within the site, namely:

- hooded robin (*Melanodryas cucullata cucullata*); and
- diamond firetail (*Stagonopleura guttata*).

No other threatened species were mentioned within the report. Eight Part Tests of Significance (under the TSC Act 1995) were completed to determine the level of potential impact on identified threatened species within the study area. It was concluded that there would be no significant impact on any species recorded within the study area as a result of the proposed bulk sampling activity.

3.1.4 HLA Envirosciences (2002C)

Ecological Investigations for Exploration Drilling, Anvil Hill – Prepared for Powercoal Pty Limited

This report was prepared to address pre-drilling assessments for five proposed bore sites within the property bounded within exploration lease 5552. The assessment was prepared to determine if the proposed bore sites contained any issues that needed to be considered in relation to potential significant impact on threatened species or endangered ecological communities.

The methods for this assessment involved a non-quantitative flora assessment for a 20 metre radius from each proposed drill site.

Two similar reports (HLA Envirosciences 2002A and 2002B) had previously been completed within the exploration lease, and any previous threatened species records from these reports were included within the assessment.

No threatened plant species were recorded during investigations of the proposed drill sites. It was concluded from this assessment that the proposed drilling was unlikely to have a significant impact on threatened species.

Fauna survey was limited to habitat assessments for target threatened species. No fauna surveys were completed at the proposed drill sites. The following threatened fauna species were reported from previous records within the exploration lease:

- powerful owl (*Ninox strenua*);
- grey-crowned babbler (*Pomatostomus temporalis temporalis*);
- brown treecreeper (*Climacteris picumnus victoriae*);
- speckled warbler (*Pyrrholaemus sagittata*);
- glossy black-cockatoo (*Calyptorhynchus lathami*);
- diamond firetail (*Stagonopleura guttata*); and
- hooded robin (*Melanodryas cucullata cucullata*).

It was concluded from this assessment that the proposed drilling was unlikely to have a significant impact on threatened species.

3.1.5 Abel Ecology (2005)

Flora and Fauna Report for Lot 168 Bells Lane, Denman in the Upper Hunter Valley New South Wales – Prepared for Anvil Hill Project Watch Association Incorporated

This report was funded by an Envirofund grant from the Australian Government, for the purpose of identifying and protecting the indigenous heritage, flora and fauna characteristics of a "key 425 acre property that is part of a natural corridor between the Wollemi National Park and the Manobalai Nature Reserve" (Abel Ecology 2005). The property is privately owned, and will be hereafter referred to as the Envirofund site.

Flora and fauna surveys were completed within the Envirofund site to identify significant ecological features (endangered ecological communities, endangered populations, threatened species, or their habitats), as well as to determine the conservation value of the property.

Field surveys for this purpose were conducted on 8 – 9 May 2003, 11 – 13 March 2004, June 2004, September 2004, 1 – 4 October 2004 and April 2005. These were conducted by Abel Ecology, as well as a number of other government and community based organisations, and volunteers.

Flora surveys of the Envirofund site do not appear to have included systematic plot based surveys or transects. Rather, surveys appear to be based on random meander recordings of flora species with the use of a global positioning system (GPS) for recording significant observations. Target searches were completed for a number of rare or threatened flora species considered to have potential habitat within the Envirofund site, these being *Commersonia rosea,* narrow goodenia (*Goodenia macbarronii*)*, Pomaderris queenslandica, Pomaderris reperta,* painted diuris (*Diuris tricolor*)*,* lobed bluegrass (*Bothriochloa biloba*)*,* mountain grevillea (*Grevillea montana*) and weeping myall (*Acacia pendula*)*.*

The identification of vegetation communities within the Envirofund site was based on the existing mapping completed by the Hunter-Central Rivers Catchment Management Authority (HCRCMA) (Peake 2005). This vegetation mapping identified the following vegetation communities within the Envirofund site (following Peake 2005):

- Central Hunter Box – Ironbark Woodland;
- Hunter Narrabeen Footslopes Exposed Ironbark – Callitris Woodland;
- Narrabeen Footslopes Slaty Box Woodland;
- Central Hunter Paperbark Soaks Woodland;
- Central Hunter Bulloak Forests Regeneration; and
- Upper Hunter Coastal Myall Exposed Forest.

Rare or threatened flora species recorded as being identified within the Envirofund site include:

- painted diuris*;*
- *Pomaderris reperta*; and
- mountain grevillea.

A number of other threatened species were reported as being recorded in nearby or adjoining areas outside of the Envirofund site.

The record of *Pomaderris reperta* was located “approximately directly adjacent to the centre of the existing western fence line, approximately 50 m inside of the actual western boundary” (Abel Ecology 2005). This boundary adjoins the Anvil Hill Study Area.

Both painted diuris and narrow goodenia were reported from “locations within the nearby area to the north-west of the Envirofund site” (Abel Ecology 2005), presumably within the Anvil Hill Study Area.

Lobed bluegrass was recorded from grassland areas to the south of the Envirofund site.

Surveys of the Limb of Addy Hill area identified *Commersonia rosea* from the lowlands off the northern tip of the Limb of Addy Hill; *Lasiopetalum longistamineum* from the top of the Limb of Addy Hill; *Pomaderris reperta* from the western slopes; and *Pomaderris queenslandica* from the southern slopes of the Limb of Addy Hill. All of these sites are located within the Proposed Offset Areas of the Anvil Hill Study Area.

Fauna surveys were completed within the Envirofund site to identify significant ecological features (endangered populations, threatened species, or their habitats), as well as to determine the conservation value of the property.

Field surveys for this purpose were conducted on 8 – 9 May 2003, 11 – 13 March 2004, June 2004, September 2004, 1 – 4 October 2004 and April 2005. They were conducted by Abel Ecology, as well as a number of other government and community based organisations, and volunteers.

Fauna surveys included methods to target a large number of threatened fauna species considered to have potential habitat within the Envirofund site, including:

- spotlighting;
- micro-bat echolocation call recording;
- pitfall trapping;
- terrestrial Elliot A and B traps;
- arboreal Elliott A and B traps;
- terrestrial and arboreal hair tubes;
- cage trapping;
- signs of presence searches;
- stag-watching;
- amphibian searches;
- reptile searches; and
- bird searches.

Fauna habitat types within the Envirofund site were classified into remnant woodland (including canopy, understorey and groundcover layers), aquatic habitat in the form of dams, open grassland areas and creeklines (generally dry, but minimal flow and pooling recorded in 2005).

Threatened fauna species recorded from these surveys comprise:

- brown treecreeper (*Climacteris picumnus victoriae*);
- hooded robin (*Melanodryas cucullata cucullata*);
- diamond firetail (*Stagonopleura guttata*);
- speckled warbler (*Pyrrholaemus sagittata*);
- grey-crowned babbler (*Pomatostomus temporalis temporalis*);
- masked owl (*Tyto novaehollandiae*);
- glossy black-cockatoo (*Calyptorhynchus lathami*);
- turquoise parrot (*Neophema pulchella*);
- square-tailed kite (*Lophoictinia isura*);
- large bentwing-bat (*Miniopterus schreibersii*) currently known as eastern bentwing-bat (*Miniopterus schreibersii oceanensis*);
- eastern cave bat (*Vespadelus troughtoni*);
- koala (*Phascolarctos cinereus*) (scat identification only); and
- brush-tailed rock-wallaby (*Petrogale penicillata*) (scat identification only).

A number of other threatened species were considered to have potential habitat within the Envirofund site, however were not recorded during these surveys. Additional threatened species mentioned by this report as having been recorded in the local area, or reported from previous studies include:

- barking owl (*Ninox connivens*);
- powerful owl (*Ninox strenua*);
- osprey (*Pandion haliaetus*);
- painted honeyeater (*Grantiella picta*); and
- black-chinned honeyeater (*Melithreptus gularis gularis*).

The records of the barking owl and powerful owl are from a private property to the north of the Envirofund site, as well as to the north-west, along the eastern edge of the Study Area.

The records of the osprey and the square-tailed kite are only noted in the list of observed species in the report. No further information is provided on these records, however they were identified from the Abel Ecology/Hunter Bird Observers Club records from 2004/2005.

The painted honeyeater record was sourced from the HLA Envirosciences data (HLA Envirosciences 2002A), being from a personal observation from a local landholder. This record was described in this report as a "past record".

The black-chinned honeyeater record was sourced from the HLA Envirosciences data, however this information could not be confirmed through comparison with the HLA Envirosciences data available to Umwelt.

The report concluded that the site is of "exceptionally high conservation value", as well as of research and education potential, thus should be managed for conservation purposes.

3.2 Ecological Database Searches

In order to identify all potential threatened species, endangered populations, and endangered ecological communities with the potential to occur in the local area, a detailed assessment of ecological databases was completed. These database sources comprised:

- a 20 kilometre radius search from the centre of the Study Area from the DEC Atlas of NSW Wildlife Muswellbrook 1:100,000 Map Sheet (February 2006) (DEC 2006a);
- all species recorded from the DEC Atlas of NSW Wildlife Muswellbrook 1:100,000 Map Sheet (February 2006);
- all species recorded from the DEC Atlas of NSW Wildlife Web Search http://wildlifeatlas.nationalparks.nsw.gov.au/wildlifeatlas/watlas.jsp for the Muswellbrook 1:100,000 Map Sheet (March 2006) (DEC 2006b);
- Department of Environment and Heritage (DEH) Protected Matters Search Tool Results for a 20 kilometre radius search from the centre of the Study Area (16 January 2006);
- National Herbarium of New South Wales database searches for 20 kilometre radius from the centre of the Study Area (February 2006);
- Birds Australia database searches for 20 kilometre radius from the centre of the Study Area (February 2006); and
- Australian Museum database searches for 20 kilometre radius from the centre of the Study Area (February 2006).

The first two of these database searches were from the same source, being the DEC Atlas of NSW Wildlife Map Sheets, purchased from the DEC GIS Division. The first search was completed within a 20 kilometre radius of the Study Area to identify records from within the local area, whereas the entire map sheet was used in the second search to identify all species occurring regionally. The third search was completed using the web-based DEC Atlas of NSW Wildlife, as this resource is updated with new records more frequently. This search was completed after the preceding searches, allowing the use of the most recent Atlas resources.

Searches of both forms of the DEC Atlas of NSW Wildlife were completed prior to field survey, as well as at various stages throughout the reporting process. These results were progressively incorporated into the report. The most recent updates of these searches have been included within this report. The same process was followed for the DEH Protected Matters Search Tool.

Searches of the National Herbarium of New South Wales, Birds Australia and Australian Museum databases were completed in May 2005 and February 2006.

Records from these database searches were combined with records from a number of other sources (including literature reviews and landholder records) to form a table of potentially occurring threatened species (**Appendix A**). Also included in this table are relevant records from the literature review, previous field surveys, and professional opinion. Furthermore, a number of additional species that are not listed under the TSC Act 1995 were included such as species listed under the EPBC Act 1999 and ROTAP (Rare or Threatened Australian Plant) species considered likely to have potential habitat within the Study Area.

The information contained within this table was then used to assist in the development of the survey methods, as particular attention was paid to targeting potentially occurring threatened species, endangered populations and endangered ecological communities during field surveys.

3.3 Flora Survey Effort

The main components of the flora survey consisted of a literature review, database searches and field survey. The process for literature review and database searches has been described above, while the components of the field survey are further detailed below.

3.3.1 Current Survey

The flora survey was based on the use of systematic plot-based sampling and extensive targeted threatened flora survey transects (**Figure 3.1**). These are described individually in the following sections. In total, 44 ten-hour person-days were used to comprehensively sample the vegetation communities and flora of Study Area.

3.3.1.1 Systematic Plot-based Survey

The plot-based vegetation survey was undertaken using methods that are more or less standard in most NSW government vegetation management agencies (for example DEC, Royal Botanic Gardens Sydney and Department of Natural Resources). The same approach was also utilised by other local vegetation surveys (for example by Bell 1997, 1998; Hill 2000; and Peake 1999, 2006). This ensured that data collected by other surveys could be incorporated into the current work, and that the data from the current study could be analysed in an equivalent way to that collected by other recognised studies.

When undertaking systematic sampling to assist vegetation community mapping and description, plot-based (or quadrat) surveys have several distinct advantages over non-quantitative transects, including:

- providing a quantitative examination of species distribution and abundance;
- being likely to detect inconspicuous or rare species (especially forbs and grasses) within the given sampling area as a smaller area is surveyed in a concentrated search; and
- providing a basis for any subsequent monitoring required.

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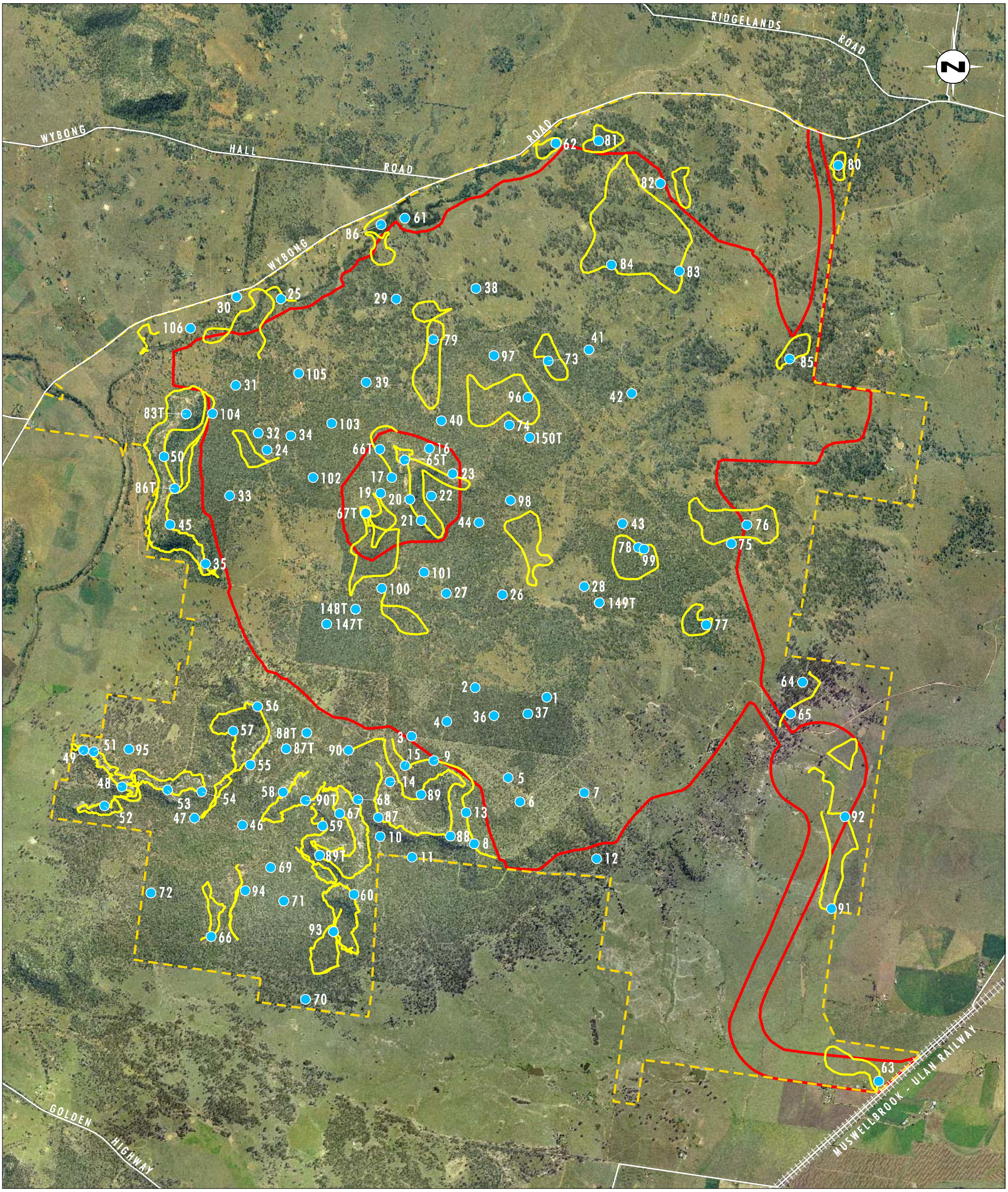

Source: HLA Envirosciences (2003), Hunter-Central Rivers CMA (1999)
Base Map: Dept. of Lands (2003), ortho-rectified by Plateau Images

Legend

Proposed Disturbance Area
Study Area
Walking Transects
47 Umwelt Flora Survey Sites
150T Hunter-Central Rivers CMA Flora Survey Sites

FIGURE 3.1

Flora Survey Locations

File Name (A4): R01_V1/1858_334.dgn

Systematic survey sites were selected by considering a range of attributes that were considered to influence or determine the type of vegetation communities present. This stratification was done intuitively, but based on existing topographic, soil, vegetation and geological mapping. Other factors considered included the spacing of sites across the overall Study Area, as well as topographic position (**Schematic 3.1**) and aspect.

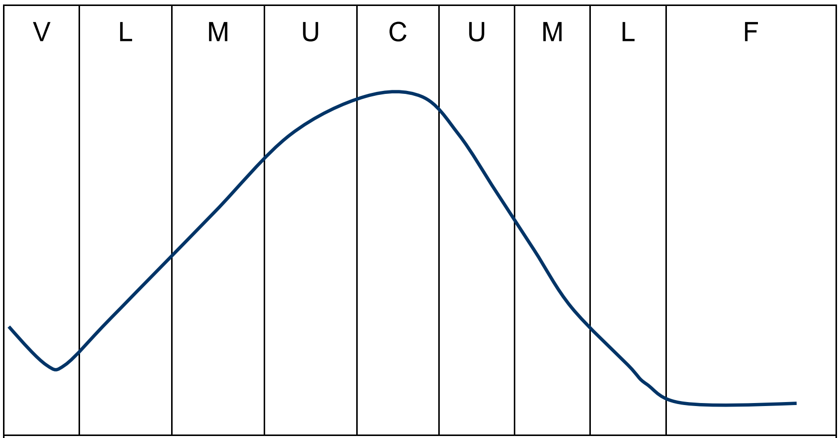

Diagram of simplified cross section of land showing:

- **crest (C)**
- **upper slope (U)**
- **mid slope (M)**
- **lower slope (L)**
- **valley (V)**
- **flat (F)**

Schematic 3.1: Topographic positions sampled in the field survey

Data on topography, soil type and geology were sourced from existing government maps, while general data on vegetation communities were sourced from Peake (2006). The vegetation map was later refined based on the results of botanical field surveys. This is discussed in **Section 4.2**. Plot data sourced from other studies was also utilised in the vegetation mapping.

Not all stratification was done a priori, as the selection of survey sites in the field was undertaken to ensure that obvious variability in aspect, slope, elevation and micro-terrain were sampled.

Plots were located to sample each stratification unit as representatively as possible, while recognising the limitations in finding representative locations within inherently heterogenous vegetation communities. The location of each plot was recorded using a 1:25,000 topographic map sheet, as well as a GPS. During the course of the surveys, the Map Grid of Australia (MGA) coordinate system was used.

Systematic 400 m^2 plots were used to undertake semi-quantitative sampling of vegetation. This plot size is used widely, including by the Royal Botanic Gardens Sydney and DEC. The typical dimensions of the plot are 20 metres by 20 metres, although in some places this was altered to 10 metres by 40 metres to account for some linear vegetation communities, particularly along watercourses.

At each plot, roughly 45 to 60 minutes were spent searching for all vascular flora species present within the plot. Two ecologists were present at each sampled plot, and typically one searched while the other recorded and undertook complementary searching. Searches of each plot were generally undertaken through parallel transects from one side of the plot to another. Most effort was spent on examining the groundcover, because at most sites this supported well over half of all species. However, at each plot the surveys also thoroughly examined the shrub layer, mid-understorey, canopy and emergents. Effort was made to search the canopy and tree trunks for mistletoes, vines and epiphytes.

Species within the plot were assigned a cover-abundance value (**Table 3.1**) to reflect their relative cover and abundance in the plot. A modified Braun-Blanquet 6-point scale (Braun-Blanquet 1927, with modifications by Poore 1955 and Austin et al. 2000) was used to estimate the cover-abundances of all plant species within each plot.

Table 3.1 - Modified Braun-Blanquet Crown Cover-abundance Scale

Class	Cover-abundance*	Notes
1	Few individuals (less than 5% cover)	Forbs, sedges and grasses: < 5 individuals Shrubs and small trees: < 5 individuals
2	Many individuals (less than 5% cover)	Forbs, sedges and grasses: 5 or more individuals Shrubs and small trees: 5 or more individuals Medium-large overhanging tree
3	5 – less than 20% cover	
4	20 – less than 50% cover	
5	50 – less than 75% cover	
6	75 – 100% cover	

Note: * Modified Braun-Blanquet scale (Braun-Blanquet 1927; Poore 1955; Austin et al. 2000).

Any species observed outside the plot but within the vegetation community being sampled were recorded, but detailed systematic searches were not made outside the plot. These species were noted as being present but were not assigned any cover-abundance values and were not used in subsequent analyses. A recording pro forma was used to record plant species cover-abundance data.

3.3.1.2 Targeted Threatened Flora Transects

Targeted flora transects are useful for detecting threatened flora species across large areas, as they enable the surveyor to cover large proportions of the area under investigation, unlike plot-based surveys.

Extensive dedicated transects were walked across most of the Study Area to search for threatened flora species (**Figure 3.1**). Transects were variable in length and location, and were tailored to suit the environment in which they occurred. In total, approximately 73 kilometres of walking was undertaken by two ecologists. In all cases, searches were made in all strata, above and below rock faces, and around dams and riparian areas.

3.3.1.3 Plant Identification and Taxonomic Review

All vascular plants were identified using keys and nomenclature in Harden (1992, 1993, 2000 & 2002), and Wheeler et al. (2002). Where known, changes to nomenclature and classification have been incorporated into the results, as derived from *PlantNET* (Botanic Gardens Trust 2006), the on-line plant name database maintained by the National Herbarium of New South Wales. Names revised since Harden (1992, 1993, 2000 & 2002) and Wheeler et al. (2002) and used in this study are listed in **Table 3.2**.

Table 3.2 - Revisions or additions to botanical nomenclature used in this report

Species or group revised	Reference
Agrostis revision and instalment of *Lachnagrostis*	Jacobs (2001)
Bursaria revision	Cayzer et al. (1999)
Canthium transferral to *Psydrax*	Reynolds and Henderson (2004)
Centipeda revision	Walsh (2001)
Commersonia rosea circumscription	Bell & Copeland (2004)
Conyza revision	Walker (1971)
Danthonia/*Austrodanthonia*/*Notodanthonia* revisions (includes *Chionochloa* revision)	Linder & Verboom (1996); Linder (1997)
Ficus rubiginosa f. *rubiginosa*	Dixon (2002); Dixon et al. (2001)
Gnaphalium revision & transferral to *Euchiton* and *Gamochaeta*	Anderberg (1991)
Pandorea pandorana revision	Green (1990)
Parsonsia revision	Williams (1996)
Solanum brownii revision	Bean (2002)
Sporobolus revision	Simon & Jacobs (1999)
Stipa/*Austrostipa* revision	Jacobs & Everett (1996)
Triglochin procerum revision	Aston (1995)
Verbena revisions	Michael (1995, 1997a & 1997b); Munir (2002)

Common names used follow Harden (1992, 1993, 2000 & 2002) where available, and draw on other sources such as local names where these references do not provide a common name.

Plants that were not able to be identified were forwarded to the National Herbarium of New South Wales at the Royal Botanic Gardens Sydney. Specimens of *Pomaderris* were sent to Mr Neville Walsh of the National Herbarium of Victoria.

3.3.1.4 Biases and Limitations

This survey was less affected by limitations in time and by seasonal influences than is usually the case because it was conducted during all seasons and over two years. The use of consistent surveyors for a large proportion of the sampling effort also helped to minimise observer bias that inevitably occurs during intensive sampling regimes that are undertaken by more than one surveyor. Despite this, specific surveys conducted during some of the drier parts of the overall survey period were affected by the impact of drought conditions on plant flowering and fruiting.

For herbaceous and graminoid species, such as those belonging to the families Asteraceae, Orchidaceae, Cyperaceae and Poaceae, the allocation of specimens to sub-specific levels was, as always occurs during flora surveys, affected by the availability of adequate flowering of fruiting material. In this case specimens were always forwarded to the National Herbarium of New South Wales if they were considered to be of potential significance or importance.

Some ephemeral species may not have been detected due to the aforementioned drought conditions. Species such as the ephemeral forb narrow goodenia (*Goodenia macbarronii*), which had been detected by earlier surveys that occurred outside of drought periods (HLA Envirosciences 2002A), were detected only in very low abundance during the Umwelt survey.

3.3.2 Total Flora Survey Effort

The total flora survey effort consisted of surveys conducted by three organisations for different purposes (**Section 3.1**). The botanical surveys undertaken by the HCRCMA were conducted between 2 September 1999 and 17 July 2001; HLA Envirosciences botanical surveys were conducted between 19 February and 16 May 2002; and Umwelt surveys were completed between 23 March 2004 and 24 May 2005.

Flora surveys were undertaken during the following months and seasons:

- summer (December, February);
- autumn (March, April, May);
- winter (June, July); and
- spring (September, October).

Seventy approximate ten-hour person-days of flora surveys by Umwelt and HLA Envirosciences staff were spent in the field undertaking specific botanical surveys. The data used for this assessment also draws upon a further 13 plots sampled by the HCRCMA, equalling a further estimated six ten-hour person days of botanical survey.

As a result of all botanical surveys, the following total sampling effort was conducted:

- 141 20 x 20 metre plots sampled (Umwelt, HLA Envirosciences and HCRCMA); and
- approximately 73 kilometres of threatened flora search transects.

Figure 3.1 displays the location of all Umwelt and HCRCMA plots, as well as the threatened flora walking transects.

In addition to this, the condition assessment surveys (see **Section 3.6**) undertaken over 16 (ten-hour) person days in December 2005, included further targeted searches for threatened flora species and ground-truthing of vegetation mapping. A copy of the proforma used for the condition assessment surveys is provided in **Appendix B**.

3.4 Vegetation Mapping

Vegetation mapping was undertaken using best-practice techniques to delineate vegetation communities across both the Study Area and the local area, within three kilometres of the Study Area boundary.

Vegetation mapping involved the following key steps:

- import of licensed draft regional vegetation community mapping from the Hunter – Central Rivers Catchment Management Authority (Peake 2006);
- review of mapping undertaken by HLA Envirosciences (2002);
- preparation of draft vegetation community map based on aerial photograph interpretation of 1:25,000 stereo pairs (see below) and preliminary delineation of vegetation community floristics;

- ground-truthing of vegetation map over a one year period and based on survey effort documented in **Section 3.3.2**;
- revision of vegetation community floristic delineations based on plot data; and
- revision of vegetation map based on ground-truthing.

Vegetation communities were grouped into four vegetation formations, which were based solely on structural characteristics rather than floristic components. These comprised:

- woodland (dominated by trees of 10-40% cover and typically 6-20 m height, with or without a mid-understorey or understorey);
- shrubland (dominated by low trees or shrubs of 10-80% cover and typically 2-6 m height, with or without an understorey);
- riparian and floodplain woodland (dominated by trees of 10-80% cover and typically 6-20 m height, in a linear strip along waterways of dense, or restricted to floodplains of open, with or without a mid-understorey or understorey); and
- grassland (dominated by grasses, sedges and forbs, with trees and shrubs very sparse or absent).

Mapping was undertaken using 1:25,000 stereo pairs of photographs flown in 2003, and a mirror stereoscope, which enabled three dimensional viewing of the land surface. Vegetation boundaries were directly digitised on to a digital aerial photograph using Mapinfo geographic information system (GIS), thus avoiding traditional errors that occur through the use of overlays and multiple mappers. The digital aerial photograph was a composite of images taken in August-September 2003 (Department of Lands 2003; ortho-rectified by Plateau Images). The original photograph was captured at 1:25,000, and the resolution of the ortho-rectified image is 0.5 m per pixel.

Once vegetation mapping was complete, remnants or patches of vegetation were attributed to size classes, in accordance with similar work undertaken by Peake (2006). Four size classes were used, comprising the following:

- very large (over 100 ha);
- large (40-100 ha);
- medium (10-40 ha); and
- small (less than 10 ha).

3.5 Fauna Survey Effort

The main components of the fauna survey consisted of a literature review, database searches and field survey. The process for literature review and database searches is described in **Sections 3.1** and **3.2**, while the components of the field survey are detailed further below.

3.5.1 Current Survey

A total of 10 fauna survey periods (**Table 3.3**) were completed by Umwelt as part of this Project. The fauna survey program undertook a high level of survey effort in both the Proposed Disturbance Area and the Proposed Offset Areas. This allowed a high level of confidence when comparing the two areas, and provided a large amount of survey data and site knowledge of the ecological characteristics of the Study Area on which to base impact assessment and management options for this Project.

Table 3.3 - Umwelt Fauna Survey Periods

Timing	Duration	Location
Autumn 2004	10 days	Across whole Study Area
Spring 2004	5 days	Proposed Disturbance Area
Spring 2004	3 days	Proposed Offset Areas
Summer 2004/5	5 days	Proposed Offset Areas
Autumn 2005	5 days	Proposed Offset Areas
Autumn 2005	3 days	Across whole Study Area
Autumn 2005	2 days	Proposed Offset Areas and Proposed Disturbance Area
Winter 2005	1 day	Part of Proposed Disturbance Area
Winter 2005	3 days	Across whole Study Area
Winter 2005	1.5 days	Proposed Offset Areas (Anvil Hill)

During each of the fauna survey periods, a variety of survey techniques were employed. Each technique is described in detail in the following sections, along with the survey effort completed for each technique within the Proposed Disturbance Area and Proposed Offset Areas.

3.5.1.1 Trapping Surveys

A variety of different types of traps were used during the Project, targeting a wide range of fauna species. The trapping methods used across both the Proposed Disturbance Area and Proposed Offset Areas are detailed below, and **Table 3.4** provides a summary of the trapping effort completed within the Study Area over all survey seasons. **Figure 3.2** shows the locations of all fauna trapping surveys.

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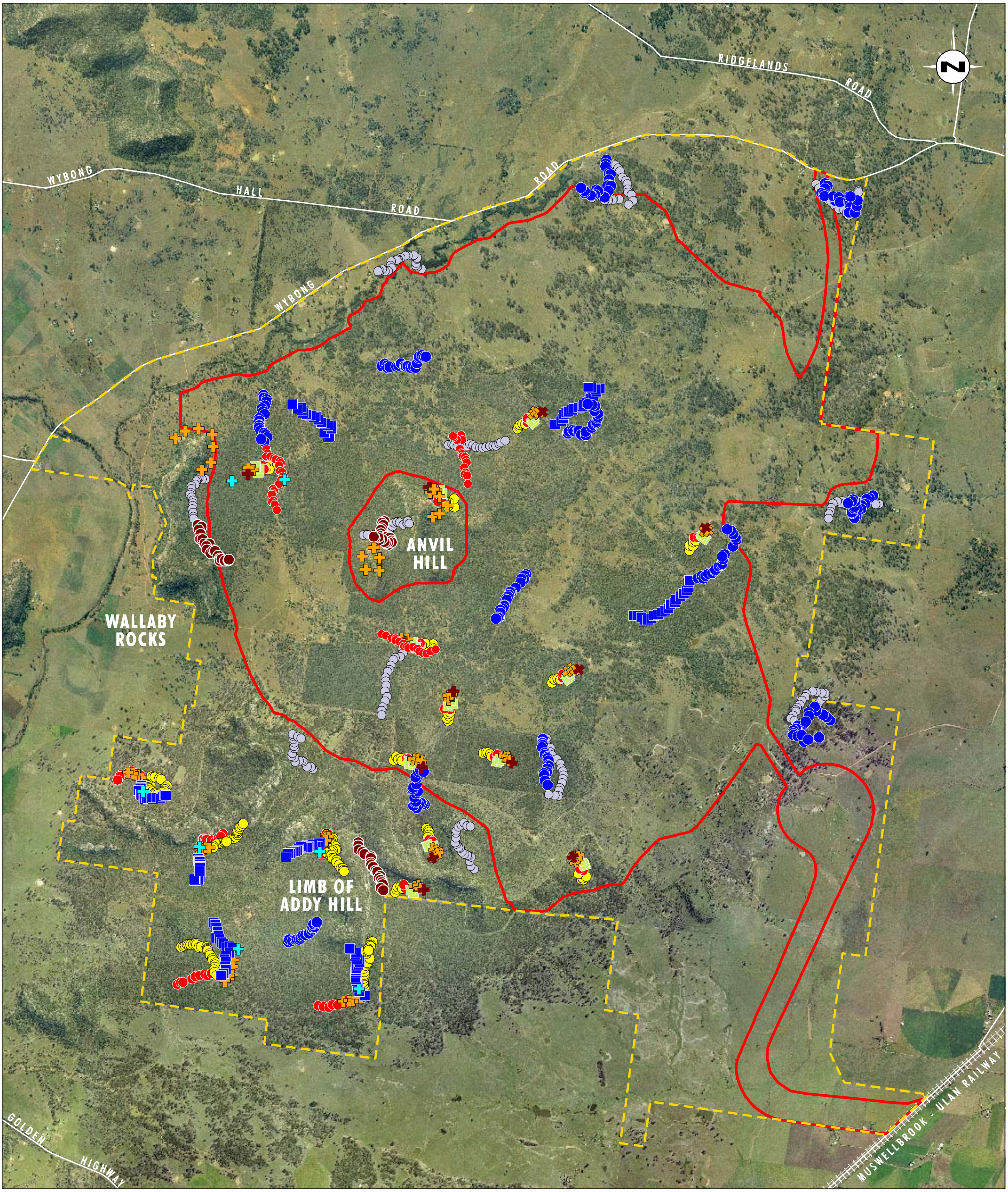


Base Map: Dept. of Lands (2003), ortho-rectified by Plateau Images

0 0.5 1.0 2km

Legend

- Proposed Disturbance Area
- Study Area
- Terrestrial Elliot A Traps
- Arboreal Elliot B Traps
- Terrestrial Meat Hair Tube
- Arboreal Hair Tubes
- Paired Hair Tubes (Oat Arboreal and Oat Terrestrial)
- Oat Hair Tube (Arboreal and Terrestrial)
- Paired Hair Tubes (Terrestrial Meat Hair Tube and Terrestrial Oat Hair Tube)
- Cage Trap
- Pitfall Trap
- Harp Trap

FIGURE 3.2

Umwelt Fauna Trapping Positions

File Name (A4): R01_V1/1858_335.dgn

Table 3.4 - Total Trapping Effort (trap nights)

		Trap Type								
	Survey Period	**Pitfall Traps**	**Terrestrial Elliott A**	**Terrestrial Elliott B**	**Arboreal Elliott B**	**Terrestrial Hair Funnel**	**Arboreal Hair Funnel**	**Harp Trap**	**Cage Trap**	**Total Combined Trap Nights**
Proposed Disturbance Area (trap nights)	Autumn 2004	30	480	8	144	72	144		128	**1006**
	Spring 2004				228	1260		6	45	**1539**
	Autumn 2005					1755				**1755**
	Winter 2005					210	2583			**2793**
Proposed Offset Areas (trap nights)	Autumn 2004	10				24	48			**82**
	Summer 2005		300	200	90	1080	3717	9	45	**5441**
	Autumn 2005		196	156	70	2178		6	35	**2641**
	Winter 2005					1050				**1050**
Total Effort (trap nights)		**40**	**976**	**364**	**532**	**7629**	**6492**	**21**	**253**	**16307**

Terrestrial Elliot Traps

Terrestrial Elliot A and Elliot B traps were set in pairs approximately 20 metres apart on the ground and baited with a mixture of rolled oats and peanut butter. All traps were positioned amongst habitat features such as logs, fallen bark, rocks and ground cover. All Elliot traps were covered with a plastic bag to prevent rain entering and were lined with woollen wadding to provide insulation for captured animals. All terrestrial Elliot traps were positioned to avoid overheating in early morning sunlight, and were tilted towards the front to prevent rain from entering the plastic bag covering the trap.

A total of 1340 terrestrial Elliot trap nights were completed across the Study Area, with a total of 976 Elliot A trap nights and 364 Elliot B trap nights completed. Terrestrial Elliot trapping was undertaken across two seasons and over two years.

Arboreal Elliot B Traps

Arboreal Elliot B traps were set approximately 30 metres apart on tree trunks, and were baited with a mixture of rolled oats, peanut butter and honey. Traps were positioned on platforms attached to the trunks of large trees, 3-4 metres above the ground. Large trees with hollows were targeted as trap sites, although traps were also set on trees without hollows. The trunk of the tree and entrance to the trap were sprayed with a honey and water mixture to attract arboreal mammals. All Elliot traps were covered with a plastic bag to prevent rain entering and were lined with woollen wadding to provide insulation for captured animals. All traps were positioned to avoid exposure to morning sunlight, and were tilted to prevent rain from entering the plastic bag covering the trap.

A total of 532 arboreal Elliot B trap nights were completed across the Study Area and surveys were completed across three seasons and over two years.

Terrestrial Cage Traps

Single ended cage traps (600 mm (L) × 300 mm (H) × 300 mm (W)) were baited with either fish-based cat food or raw chicken necks. Half of the length of each trap was covered with a clear plastic bag and shade cloth to provide rain, wind and shade protection for captured animals. All cage traps were positioned to avoid exposure to early morning sunlight, and were tilted to prevent rain from entering the trap. Traps were positioned on level ground or amongst vegetation where the trap was unable to roll away if a captured animal struggled within the trap.

A total of 253 terrestrial cage trap nights were completed across the Study Area. Terrestrial cage trapping was undertaken across three seasons and over two years.

Terrestrial Hair Funnels and Hair Tubes

Three styles and two sizes of terrestrial hair funnels or tubes were utilised as part of the fauna survey. Large Faunatech style hair funnels and large (90 millimetre) single opening PVC hair tubes were baited with either meat (fish-based cat food or raw chicken necks) or a rolled oats and peanut butter mixture, depending on the target species at the survey site. Small (50 millimetre) double opening PVC hair tubes were baited with a rolled oats and peanut butter mixture. All terrestrial hair funnels and tubes were positioned amongst habitat features such as logs, fallen bark, rocks and ground cover. Faunatech style hair funnels were pegged in position with small tent pegs while PVC style hair tubes (large and small) were placed unrestrained on the ground amongst ground cover to prevent them rolling away. All hair tubes were left in position for a minimum of ten nights and all hair samples were identified by Barbara Triggs (a recognised expert in this field) of Dead Finish, Victoria.

A total of 7629 terrestrial hair funnel or tube sampling nights were completed across the Study Area. This involved a total of 3297 and 4332 hair funnel or tube nights in the Proposed Disturbance Area and Proposed Offset Areas, respectively. Terrestrial hair funnel or tube sampling was undertaken across four seasons and over two years.

Arboreal Hair Funnels and Tubes

Large Faunatech style hair funnels and large (90 millimetre) single opening PVC hair tubes were baited with a rolled oats, peanut butter and honey mixture. All arboreal hair funnels or tubes were positioned three to four metres above the ground on tree trucks or branches. The entrances of the hair funnel or tube and the tree trunk or branch were sprayed with a honey and water mixture. Arboreal hair funnels or tubes were tilted to prevent rain entering. All hair funnels or tubes were left in position for a minimum of ten nights and all hair samples were identified by Barbara Triggs (a recognised expert in the field) of Dead Finish, Victoria.

A total of 6492 arboreal hair funnel or tube sampling nights were completed across the Study Area. A total of 2727 and 3765 hair funnel or tube nights were completed in the Proposed Disturbance Area and Proposed Offset Areas, respectively. Arboreal hair funnel or tube sampling was undertaken across three seasons and over two years.

Harp traps

Harp traps were positioned along potential micro-bat flyways such as existing tracks and gaps in the vegetation. Traps were also positioned in areas protected from exposure to the morning sun. During the day, any captured bats were kept in small calico bags and were hung inside a specifically designed animal holding box which was kept in a cool, sheltered position. All bats were released at dusk on the day of capture, after they had awoken from daily torpor. Harp traps were also inspected during nocturnal surveys such as spotlighting, and any captured bats were released immediately following identification if identification was undertaken at night.

A total of 21 harp trap nights were completed, with six and 15 harp trap nights completed in the Proposed Disturbance Area and Proposed Offset Areas, respectively. Harp trapping was undertaken across three seasons and over two years.

Pitfall Traps

Pitfall traps consisted of a 20 litre plastic bucket buried in the ground and positioned centrally along a drift fence, which was 0.2 metre high and ten metres long. The drift fence was held taught by 0.5 metre long and ten millimetre diameter steel rods driven into the ground. Five millimetre diameter steel rods were positioned along the length of the drift fence to prevent it from falling over. The drift fence was buried ten millimetres into the ground and all potential obstacles (sticks, rocks, dirt clumps etc) were removed from 50 millimetres on either side. Pitfall traps were positioned to avoid areas of significant run-off and areas of high ant, wildlife or domestic stock activity.

A total of 40 pitfall trap nights were completed across the Study Area, with a total of 30 and 10 nights completed in the Proposed Disturbance Area and Proposed Offset Areas, respectively. Pitfall trapping was undertaken across one season in one year.

3.5.1.2 Area Searches

A variety of area searches of differing duration and purpose were undertaken as part of the fauna survey. The area searches used across the Study Area are detailed below, and

Table 3.5 provides a summary of the area search effort completed within the Study Area over all survey seasons. **Figure 3.3** provides the locations of all area searches.

Table 3.5 - Area Search Effort Summary

	Total Person Hours					
	Walking Spotlighting Searches	**Driving Spotlighting Searches**	**Diurnal amphibian and reptile**	**Nocturnal reptile and amphibian**	**Bird Searches**	**Targeted Habitat Searches**
Proposed Disturbance Area	10	9	11	5	14	4.5
Proposed Offset Areas	13	10	15	10	18	64.5*
Total	**23**	**19**	**26**	**15**	**32**	**69**

Note: * All cliffs, rocky outcrops, caves and overhangs occur in the Proposed Offset Areas. Substantial time was spent searching those areas for signs of presence of the brush-tailed rock-wallaby (Petrogale penicillata) and threatened microbats.

Spotlighting Searches

Spotlighting searches were undertaken both on foot and from a moving vehicle. Walking spotlighting searches were undertaken by two observers for a period of at least 30 minutes (total of one person hour) on each occasion. Vehicle spotlighting searches were undertaken by the passenger(s) from a slowly moving (first gear, low range) four wheel drive vehicle for a minimum of one kilometre. Walking and vehicle spotlighting searches were undertaken using 30 watt Lightforce spotlights.

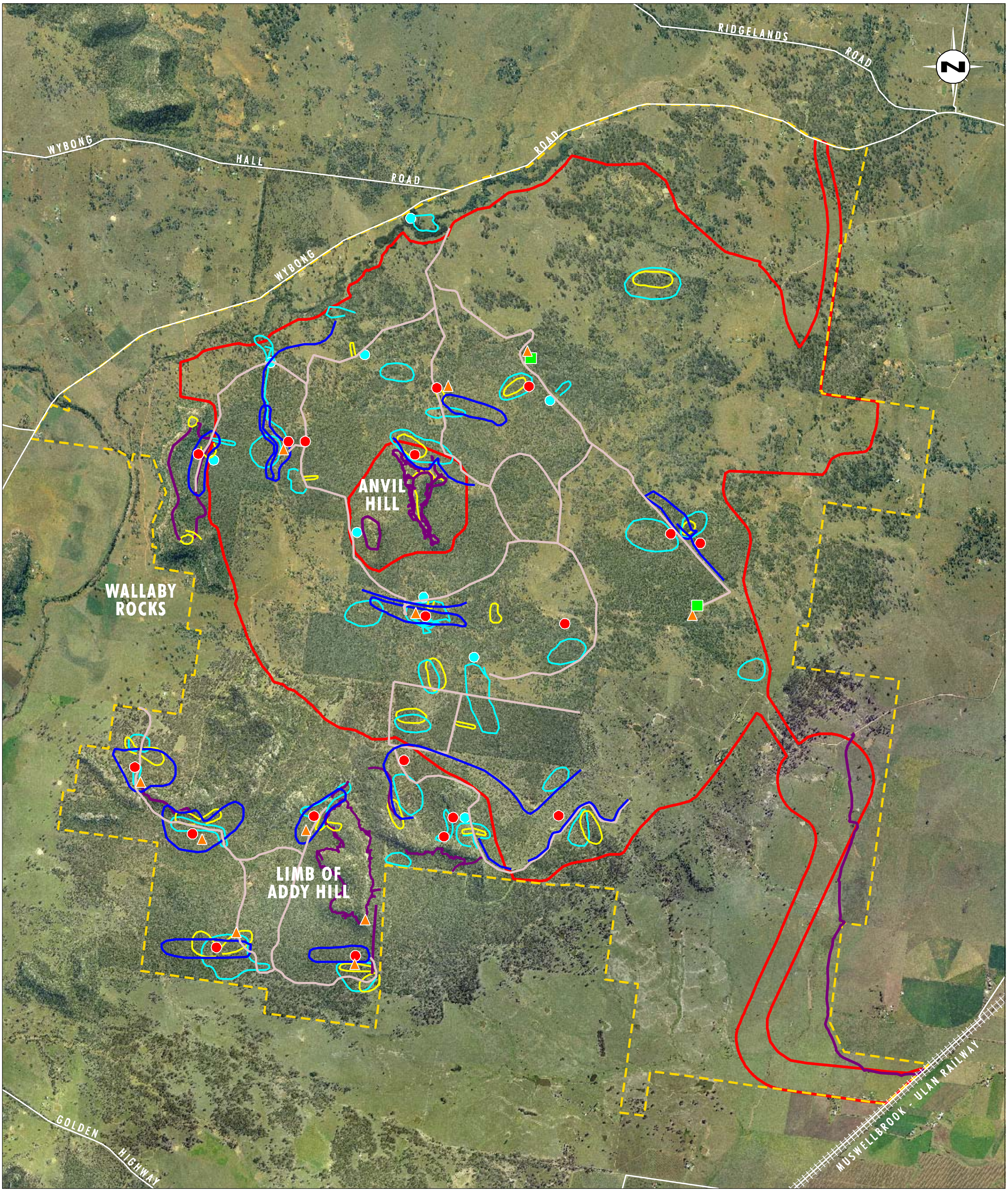
A total of 23 walking person hours and 19 driving person hours of spotlighting searches were completed across the Study Area. Of these 19 hours were completed in the Proposed Disturbance Area (10 walking hours and 9 driving hours) and 23 hours in the Proposed Offset Areas (13 walking hours and 10 driving hours).

Reptile and Amphibian Searches

Diurnal searches specifically targeting reptiles and opportunistically targeting amphibians were undertaken during the warmest parts of the day. Nocturnal searches targeted amphibians and nocturnal reptile species. All reptile and amphibian searches were undertaken by two ecologists for a period of at least 30 minutes. Nocturnal reptile and amphibian searches were undertaken using Petzel headlamps and/or 30 watt Lightforce spotlights.

Habitat features investigated during reptile and amphibian searches included water bodies, emergent vegetation, wet soak areas, logs, rocks, loose bark on tree trunks, exposed bedrock, leaf litter and open grassland areas. Amphibians not identifiable from their calls were captured for visual identification. All amphibians were handled according to the DEC hygiene protocol for the control of disease in frogs (NPWS 2001). Non-venomous snake species and small lizards were captured for identification.

A total of 41 hours of reptile and amphibian searches were completed across the Study Area. A total of 11 and 15 hours of diurnal reptile and amphibian searches were completed in the Proposed Disturbance Area and Proposed Offset Areas respectively. A total of 10 hours of nocturnal reptile and amphibian searches were undertaken in the Proposed Offset Areas,



Base Map: Dept. of Lands (2003), ortho-rectified by Plateau Images

0 0.5 1.0 2km

Legend

- Proposed Disturbance Area
- Study Area
- Reptile Transect
- Bird Transect
- Habitat Search
- 4WD Spotlight Transect
- Walking Spotlight and Anabat Transect (often including herpetological searches)
- Diurnal Call Playback
- Nocturnal Call Playback
- Anabat Echolocation (overnight recording)
- Nocturnal Amphibian Search

FIGURE 3.3

Umwelt Diurnal and Nocturnal Fauna Area Search Effort

with five hours of nocturnal amphibian searches undertaken in the Proposed Disturbance Area during autumn 2004.

Bird Searches

Bird surveys were undertaken in a range of different habitat types at various times of the day, primarily in early to mid morning and mid to late afternoon. Bird searches were undertaken by one observer for a minimum of one hour or by two observers for a minimum of 30 minutes. Opportunistic observations were recorded during all other aspects of the field survey, particularly while checking traps and when travelling between survey sites. Bird species were identified from characteristic calls and by observation using a 15 - 45 × 50 spotting scope or 10 × 60 binoculars.

A total of 32 hours of bird searches were completed, with 14 and 18 hours of bird searches completed in the Proposed Disturbance Area and Proposed Offset Areas, respectively.

Targeted Habitat Searches

Targeted habitat searches were undertaken throughout the survey, focusing on threatened fauna species occurring within specific habitat types. Such surveys included target searches of rocky outcrops and cliff lines for fauna groups such as rock wallabies, reptiles and micro-bat colonies. Where it was considered safe to do so, overhangs and caves were searched for signs of presence such as tracks, scats, pellets, nests and hair. In many cases, caves or overhangs could not be reached safely and were not inspected. All caves, cliffs, rocky outcrops and overhangs occur within the Proposed Offset Areas, therefore most searches targeted this area.

Signs of Presence Searches

Searches for evidence of animal presence were conducted opportunistically during all survey activities, particularly during habitat searches and reptile and amphibian searches. Due to the opportunistic nature of signs of presence surveys the level of survey effort was not recorded. Evidence of presence included scats, feathers, nests, burrows, bones, tufts of hair and scratch marks on trees. All hair, scat and bone samples were identified by Barbara Triggs (a recognised expert in the field) of Dead Finish, Victoria.

3.5.1.3 Recordings and Call Playback Surveys

Micro-bat Echolocation Recordings

During the survey period, two different micro-bat echolocation recording devices were used and two different durations of recordings were made. Echolocation calls were detected using an Anabat II Bat Detector. During 2004 and autumn 2005, echolocation calls were recorded onto cassette tapes. From spring 2005, echolocation calls were recorded digitally onto memory cards using an Anabat CF storage ZCAIM. The combination of detector and recording device will hereafter be collectively referred to as the “Anabat echolocation recorder”. Echolocation recordings were collected either during walking transects (typically of one hour duration) or during fixed position all night recordings.

Walking micro-bat echolocation recordings were made during walking spotlight searches and nocturnal reptile and amphibian searches. These searches were completed for a minimum of 30 minutes each, however they mostly ran for 60 minutes. The Anabat echolocation recorder was placed in a backpack, positioned vertically and given a clear view of the sky. All walking transects were completed within the first four hours after dusk.

The location of the all night Anabat echolocation recorders varied depending on forecast weather patterns. During nights where rain was considered likely, the Anabat echolocation recorders were positioned on small platforms three to four metres above the ground on tree trunks. The recorders were positioned horizontally, with a small roof protecting the detector from rain. This enabled the Anabat echolocation recorders to capture calls regardless of weather conditions. While micro-bat activity is likely to be reduced during rain, calls were still able to be collected during dry parts of the night (particularly nights with brief thunderstorms). During nights where rain was considered unlikely, Anabat echolocation recorders were positioned on the ground at an approximate 30 degree angle, directed towards areas of anticipated micro-bat activity.

All night Anabat echolocation recorders were positioned with a clear view of potential micro-bat flyways. The recorders were automated and programmed to start recording one hour before dusk and to stop recording one hour after sunrise the following morning. All night recordings were collected over one to four nights at any single Anabat echolocation recording location. **Table 3.6** shows the level of survey effort during micro-bat echolocation recording surveys.

Table 3.6 - Recordings and Playback Search

	Micro-bat Echolocation Recording Walking Transects (Hours)	**Micro-bat Echolocation Recording All Night (Nights)**	**Diurnal Call Playback (Sessions)**	**Nocturnal Call Playback (Sessions)**
Proposed Disturbance Area	9	8	10	7
Proposed Offset Areas	15	19	10	2
Total	**24**	**27**	**20**	**9**

Note: One walking transect equals a minimum of 30 minutes of survey. One fixed position all night recording equals one detector at one site for an entire night.

All Anabat detector recordings were analysed by Glenn Hoye (a recognised expert in the field) of Fly by Night Surveys Pty Limited. The echolocation calls of species were identified to one of three levels of confidence:

- Confident;
- Probable; and
- Possible.

For the purposes of this assessment, all three levels of confidence were treated as positive identifications.

Call Playback

Both nocturnal and diurnal call playback sessions were undertaken. Calls were broadcast using a 10 watt directional loud hailer and all nocturnal call playback sessions were undertaken within the first four hours after dusk. Diurnal call playback sessions were undertaken at various times during the day. Call playback sessions commenced with a quiet listening period of approximately five minutes. **Table 3.6** shows the level of survey effort during call playback surveys. Each species call was played for a minimum of four minutes followed by a listening period of two minutes before the beginning of the next species call

Mammal calls were played before bird calls to prevent the calls of predators (such as owls) decreasing the likelihood of prey species (such as gliders) responding to call playback. Autumn 2004 nocturnal call playback sessions included the calls of threatened forest owls only. Subsequent sessions included the calls of:

- sugar glider (*Petaurus breviceps*);
- squirrel glider (*Petaurus norfolcensis*);
- koala (*Phascolarctos cinereus*);
- Australian owlet nightjar (*Aegotheles cristatus*);
- barn owl (*Tyto alba*);
- masked owl (*Tyto novaehollandiae*);
- barking owl (*Ninox connivens*); and
- powerful owl (*Ninox strenua*).

Diurnal call playback sessions included the calls of:

- koala;
- grey-crowned babbler (*Pomatostomus temporalis temporalis*);
- diamond firetail (*Stagonopleura guttata*);
- speckled warbler (*Pyrrholaemus sagittata*);
- brown treecreeper (*Climacteris picumnus*);
- hooded robin (*Melanodryas cucullata cucullata*);
- swift parrot (*Lathamus discolor*);
- regent honeyeater (*Xanthomyza phrygia*);
- painted honeyeater (*Grantiella picta*);
- glossy black-cockatoo (*Calyptorhynchus lathami*);
- superb parrot (*Polytelis swainsonii*), and;
- bush stone curlew (*Burhinus grallarius*).

3.5.1.4 State Environmental Planning Policy No. 44 - Koala Habitat Survey Methods

Any development application in a SEPP 44 specified local government area, affecting an area of one hectare or greater, must be assessed under SEPP 44. Assessment under SEPP 44 is based on an initial determination of whether the land constitutes potential koala (*Phascolarctos cinereus*) habitat. This is determined by assessing whether the eucalypt species present in Schedule 2 of the policy constitute 15 per cent or more of the total number of trees in the upper or lower strata of the tree component. If potential koala habitat is present, the area must be further assessed to determine if the land is core koala habitat.

The species listed in Schedule 2 of the policy are listed in **Table 3.7**.

Table 3.7 – Species of Eucalypt listed in Schedule 2 of SEPP 44

Scientific Name	Common Name
Eucalyptus tereticornis	forest red gum
Eucalyptus microcorys	tallowwood
Eucalyptus punctata	grey gum
Eucalyptus viminalis	ribbon or manna gum
Eucalyptus camaldulensis	river red gum
Eucalyptus haemastoma	broad-leaved scribbly gum
Eucalyptus signata	scribbly gum
Eucalyptus albens	white box
Eucalyptus populnea	bimble box or poplar box
Eucalyptus robusta	swamp mahogany

A total of 158 sites were assessed for the presence and percentage composition of SEPP 44 Schedule 2 tree species (**Figure 3.4**). Each site comprised a 20 by 20 metre quadrat within which the number of each tree species was counted. At most of those sites searches for koala scats were also undertaken, as part of a comprehensive condition assessment. These surveys are detailed in **Section 3.6.7** below.

The identification of potential koala habitat on the Study Area required further investigation into the likelihood of koala core habitat occurring in the Study Area. Spotlighting surveys, call playback sessions, koala scat searches, daytime visual searches of canopies and opportunistic searches were undertaken to determine the likelihood of koala core habitat present.

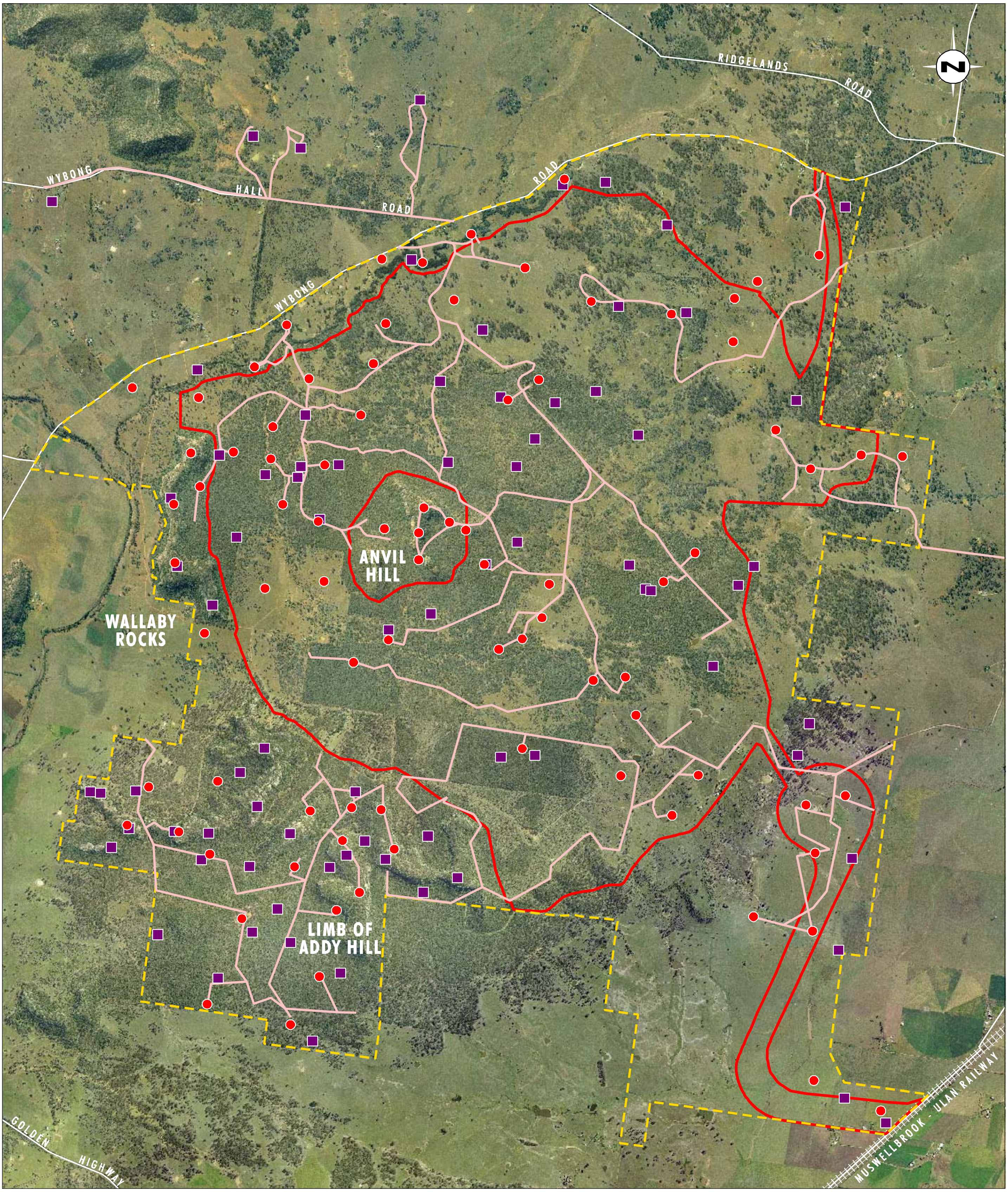
A total of 23 person hours of walking spotlight transects and 19 person hours of driving spotlight transects were completed during 2004 and 2005 (**Table 3.5** and **Figure 3.3**). A total of 29 call playback sessions including the calls of a bellowing male koala were played during daytime and nocturnal call playback sessions (**Table 3.5** and **Figure 3.3**).

3.6 Condition Assessment Survey Effort

3.6.1 Introduction to Condition Assessment

In order to inform and assist the development of a comprehensive biodiversity offsets package, an ecological condition assessment was completed across the Study Area, following the completion of other field surveys. Other stages that were undertaken prior to the ecological condition assessment included a review of vegetation community mapping, and the collation of, and preliminary assessment of, systematic flora and fauna results. This identified those key threatened species that were considered to be central to the purpose and design of the biodiversity offsets package. Consideration of these issues allowed the identification of critical components of the data to be collected during the condition assessment.

Umwelt
Environmental Consultants



Base Map: Dept. of Lands (2003), ortho-rectified by Plateau Images

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Legend

- Proposed Disturbance Area
- Study Area
- Targeted Koala Search (walking and driving)
- SEPP 44 Habitat Survey Locations
- SEPP 44 Survey Sites (Including Scat Searches)

FIGURE 3.4

SEPP 44 Koala Habitat Survey Effort

The objectives of the condition assessment were to:

- further assess and quantify the ecological condition of all vegetated environments within the Proposed Disturbance Area and Proposed Offset Areas through systematic, repeatable on-ground and remote survey methods; and
- use this information to inform and drive the biodiversity offsets strategy.

The Biodiversity Offsets Strategy for Mount Owen Mine (Umwelt 2003) was considered in formulating this assessment approach, as the condition assessment methodology for that project was determined after extensive consultation with the relevant government agencies. The DoP and DEC have previously indicated that this should be adopted as a broad model for the condition assessment for the Anvil Hill Project.

3.6.1.1 Scope of Condition Assessment

The condition assessment was designed to target vegetation communities and habitats for key threatened flora and fauna species within the Study Area. Key threatened species were defined as those that are likely to, or may possibly, be significantly impacted by the Anvil Hill Project. The development of this list of species used the following steps:

1. A list was compiled of all threatened flora and fauna species known to occur in the Study Area, known to occur in the local area, or with habitat present in the local area and therefore having the potential to occur in the Study Area (**Appendix A**). The list was based on database searches, records from Umwelt, HLA Envirosciences, HCRCMA, the Anvil Hill Project Watch Association, other references detailed in **Sections 2.3** and **2.4**, and expert opinion.

2. The presence of habitat for these species was assessed, and those species with no habitat present (and therefore no potential to occur) were excluded from further consideration.

3. All remaining species were assessed by the relevant elements of the Test of Ecological Significance (see **Section 8.8.1**). Any species considered unlikely to be significantly impacted by the Project were excluded from the final list.

Through assessing the species in this way, only those species likely to be significantly impacted, or which have some potential to be significantly impacted, remained on the list. It was these species (listed in **Tables 3.8** and **3.9**), and their habitat, that were specifically considered during the design and survey of the condition assessment.

Table 3.8 - Key threatened flora species for Condition Assessment

Common Name	Scientific Name
narrow goodenia	*Goodenia macbarronii*
painted diuris	*Diuris tricolor*

Table 3.9 - Key threatened fauna species for Condition Assessment

Common Name	Scientific Name
Birds	
glossy black-cockatoo	*Calyptorhynchus lathami*
powerful owl	*Ninox strenua*
barking owl	*Ninox connivens*
masked owl	*Tyto novaehollandiae*
Brown treecreeper	*Climacteris picumnus victoriae*
grey-crowned babbler	*Pomatostomus temporalis temporalis*
hooded robin	*Melanodryas cucullata cucullata*
speckled warbler	*Pyrrholaemus sagittata*
diamond firetail	*Stagonopleura guttata*
Mammals	
Koala	*Phascolarctos cinereus*
squirrel glider	*Petaurus norfolcensis*
Brush-tailed rock-wallaby	*Petrogale penicillata*
eastern bentwing-bat	*Miniopterus schreibersii oceanensis*
eastern false pipistrelle	*Falsistrellus tasmaniensis*
eastern freetail-bat	*Mormopterus norfolkensis*
greater broad-nosed bat	*Scoteanax rueppellii*
large-eared pied bat	*Chalinolobus dwyeri*
large-footed myotis	*Myotis adversus*
eastern cave bat	*Vespadelus troughtoni*

3.6.1.2 Summary of Condition Assessment Process

A four-step process was undertaken to complete the condition assessment of the Proposed Disturbance Area and Proposed Offset Areas. The process addressed the following questions:

- How much of each vegetation community is present?
- What is the inherent condition of each vegetation formation, and what is the condition of each vegetation formation in a landscape context?
- What are the implications for key threatened species?
- What are the implications for the biodiversity offset strategy?

Steps one to three each involved detailed comparisons of the Proposed Disturbance Area to the Proposed Offset Areas. The process involved the remote analysis of existing data, as well as the collection of substantial specific on-ground data. Data were collected in both quantitative and semi-quantitative forms wherever possible, from sites that were considered to be representative of the vegetation formations (see **Section 3.6.2.1**). The same observers were used throughout to minimise potential observer bias. Sites were replicated to minimise error, and the data were extrapolated to other parts of the target sampling unit.

Once the collected data were extrapolated to cover the entire Study Area, an analysis of the overall condition of the Potential Disturbance Area and Proposed Offset Areas was undertaken. The results of the analysis were used to inform the preparation of the Biodiversity Offsets Strategy (**Section 9**).

3.6.2 Condition Assessment Methods

3.6.2.1 Selection of Size and Location of Survey Sites

The field sampling for the condition assessment was based on stratification using vegetation formations as the base unit. Four vegetation formations were delineated as a result of the grouping of the mapped vegetation communities based on their structural characteristics (see **Section 3.4**). These were used as the basic stratification unit because the vegetation communities that formed part of each vegetation formation were more or less similar in terms of the habitat they provided for the key threatened flora and fauna species listed in **Tables 3.8** and **3.9**.

Quadrat Size

The size of the quadrat to be used as part of the condition assessment was determined from a field trial, where quadrat size and the time to complete the sampling of each quadrat were compared. Based on this trial, a quadrat size of 20 x 20 metres was selected and thereafter used.

Number of sites

The number of survey sites per vegetation formation was determined by an intuitive process that allocated a given number of sites based on the size of the vegetation formation (**Table 3.10**).

Table 3.10 - Number of Survey Sites per Vegetation Formation

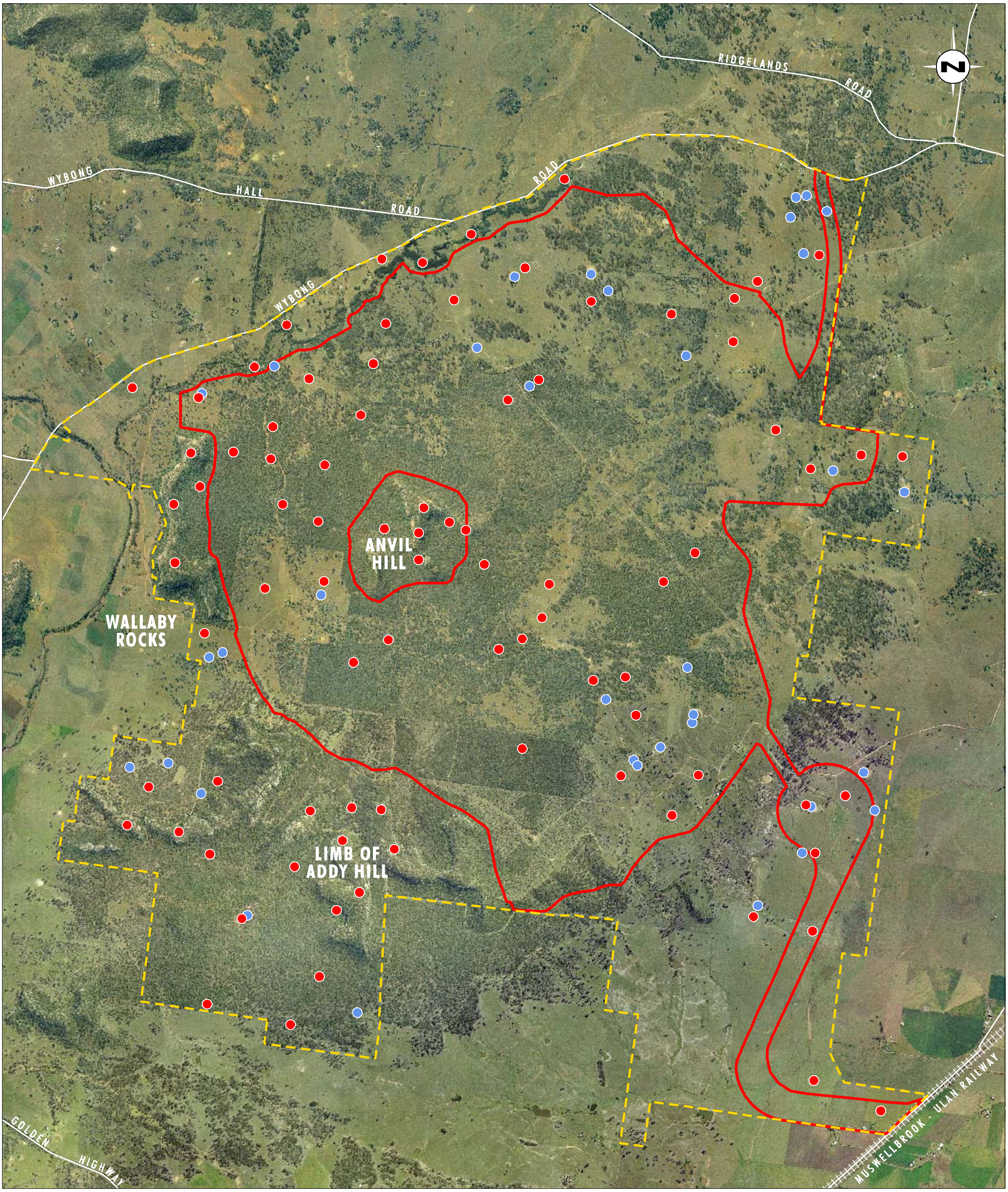
Area of Vegetation Formation (ha)	Number of survey sites
0-5	3
6-50	5
51-100	8
101-500	12
>500	15

Location of field survey sites

The locations of survey sites in the field were selected using a map of vegetation formations covering the Study Area. Individual site locations were selected to meet the following criteria:

- within 500 metres of existing vehicle tracks;
- positioned to sample the diversity of vegetation communities comprising each vegetation formation (for the three vegetation formations comprised of more than one vegetation community); and
- distributed as widely as possible to sample all areas of each vegetation formation.

Figure 3.5 shows the locations of each of the condition assessment survey sites.



Base Map: Dept. of Lands (2003), ortho-rectified by Plateau Images

0 0.5 1.0 2km

Legend

- Proposed Disturbance Area
- Study Area
- Condition Assessment Survey Sites
- Surveyed Dams

FIGURE 3.5

Condition Assessment Survey Sites

File Name (A4): R01_V1/1858_368.dgn

Individual quadrat positioning

Individual survey sites were located in the field with the use of handheld GPS units. Once within 10 metres of the location of the survey site, the nearest tree was selected as the north-eastern corner of the quadrat. A 40 metre measuring tape was walked due west for 20 metres and then due south for 20 metres to mark the northern and western sides of the quadrat. A second 40 metre measuring tape was then walked 20 metres due south from the north-eastern corner for 20 metres and then due west for 20 metres to mark the eastern and southern sides of the quadrat. All navigational bearings were identified using hand held non-digital compasses. The establishment of each site in this manner helped to reduce potential bias.

3.6.3 Collection of Habitat Data

At each quadrat the following habitat data were collected:

Physical site characteristics:

- Aspect;
- Slope;
- Soil depth; and
- Soil texture.

Disturbance Level:

- Fire history;
- Cut stump density;
- Grazing pressure level;
- Erosion severity and type;
- Weed infestation level and dominant species;
- Level of rubbish dumping; and
- Signs of feral animals.

Foliage Health:

- Dieback level;
- Mistletoe infestation level; and
- Level of foliage insect attack.

Ground Cover:

- Number and types of ground logs;
- Number and types of stumps;

- Percent rock cover;
- Percent boulder and solid rock cover;
- Ground vegetation cover percentage, dominant growth form, number of species and dominant species; and
- Understorey layer cover percentage, dominant growth form, number of species and dominant species.

Tree Cover:

- Mid-understorey layer cover percentage, dominant growth form, number of species and dominant species;
- Canopy cover percentage, dominant growth form, number of species and dominant species; and
- Diameter of up to 15 trees greater than 100 mm diameter at breast height (DBH).

Target Species Habitat Features:

- Amount of horizontal perch sites;
- Number of trees with loose bark;
- Number of trees with bark/litter mound at base;
- Number of koala (*Phascolarctos cinereus*) feed tree species; and
- Number of glossy black-cockatoo (*Calyptorhynchus lathami*) feed tree species.

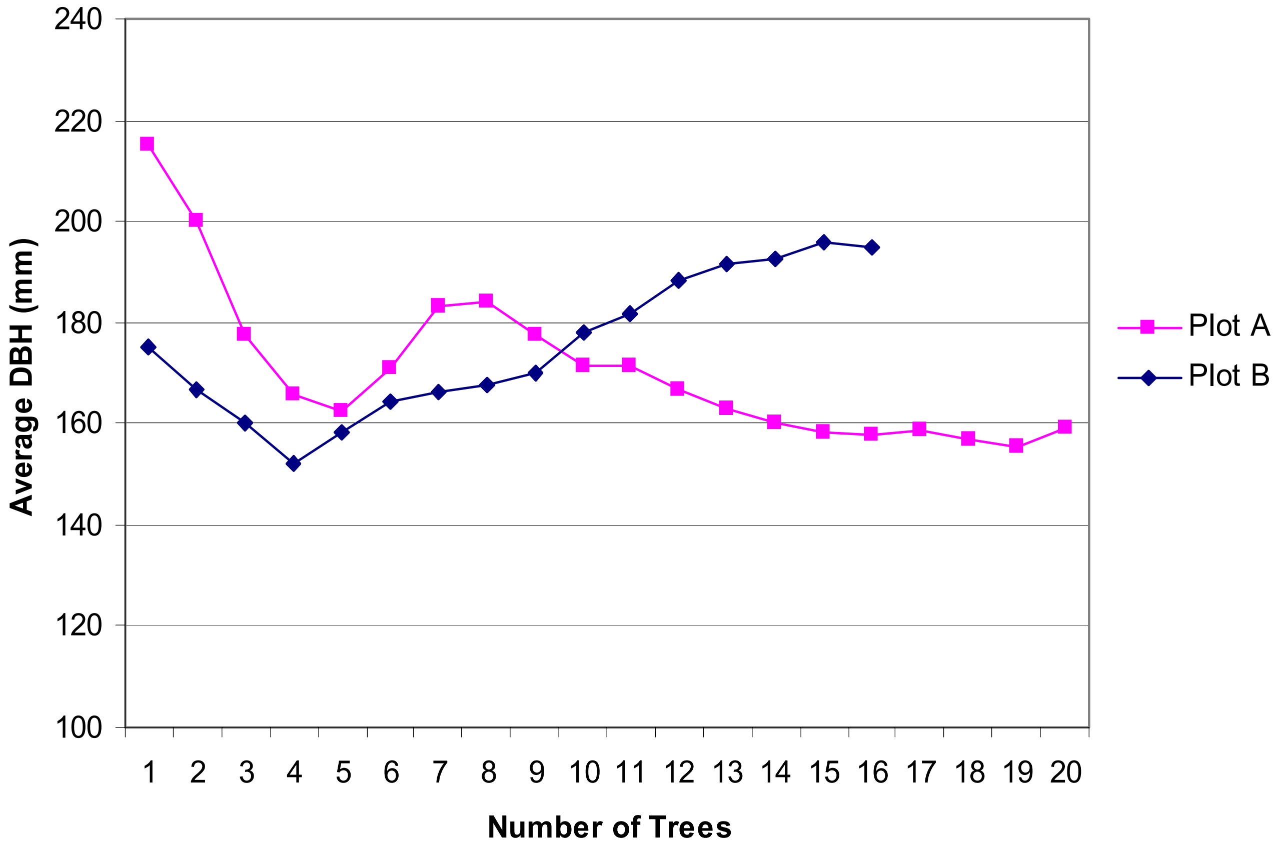
Many of the habitat parameters measured at each quadrat were scored into categories or ranges, while the remainder were derived from direct measurements. Individual categories and ranges are shown on the field proforma provided in **Appendix C**.

Counts of feed trees for the koala and glossy black-cockatoo were undertaken because those species are known to have restricted feeding preferences, and their possible presence will largely depend on the number and type of trees present.

3.6.3.1 Measurement of average DBH per quadrat

The average DBH (mm) of trees (greater than 100 mm DBH) was one of the key measurements made at each sampling site. The minimum number of trees required to determine a representative average was estimated from two trial plots, where all trees present within the quadrats were measured. Plots of the average DBH versus the number of trees measured showed a levelling of the curve at approximately 15 trees in each trial plot (**Graph 3.1**).

Not all plots sampled contained 15 trees greater than 100 mm DBH however, and in such cases all trees present were measured and the average was calculated from less than 15 trees. Where more than 15 trees greater than 100 mm DBH were present within the quadrat, the 15 closest to the north-eastern corner of the quadrat were measured, to reduce bias that could result from individual selection.



Graph 3.1 Change in the average DBH of trees in two 20 by 20 metre plots as the number of trees measured increases.

GRAPH 3.1

3.6.4 Fauna Habitat Value

To determine the relative fauna habitat values of the Proposed Disturbance Area and the Proposed Offset Areas, the method of calculating a foraging value developed by Hoye et al. (2003) was adopted and modified to form a habitat value score. Hoye et al. (2003) developed a foraging value formula to reflect the foraging value of different habitat areas. That formula was modified for this study so that the result reflected the overall habitat value for target fauna species, rather than just foraging habitat value. For example, the habitat value used here places more emphasis on roosting, nesting and denning habitat, as well as foraging habitat.

The habitat value was calculated from a formula that comprises the total area of each vegetation formation, 11 measured habitat variables considered to be important for habitat, and 11 species-specific weightings of the importance of each of the 11 habitat variables.

The habitat value formula is:

Habitat Value of Target Area X = $$\sum (T_x) \times \left\{ \left(\frac{a_n}{a_{\max}} \right)(w_a) + \left(\frac{b_n}{b_{\max}} \right)(w_b) + \ldots + \left(\frac{i_n}{i_{\max}} \right)(w_i) \right\}$$

Where:

T_x =	Total area in hectares of each vegetation formation (T_1, T_2, T_3, T_n);
a_n,b_n-i_n =	Values for each of the 11 habitat variables;
a_{max}, b_{max}-i_{max} =	Maximum variable values within the target area (Proposed Offset Areas or Proposed Disturbance Area); and
w_a,w_b-w_i =	Weighting to each habitat variable applied for a particular fauna species or fauna group.

Nine of the 11 habitat variables were sourced from Hoye et al. (2003), being:

- canopy cover percentage;
- canopy diversity (count);
- canopy height (m);
- understorey cover (%);
- understorey diversity (number);
- ground cover (%);
- ground diversity (number);
- ground logs (number); and
- hollow-bearing tree density per hectare.

Two additional habitat variables were added to the habitat value formula to adequately assess the importance of two further habitat features. Firstly, rocky outcrops with caves and crevices were recorded due to their importance for species such as the brush-tailed rock-wallaby (*Petrogale penicillata*), cave dependent micro-bats and owls. Secondly, stands of drooping sheoak (*Allocasuarina verticillata*) were recorded due to their importance for the glossy black-cockatoo (*Calyptorhynchus lathami*).

Each habitat variable was given an intuitive weighting for each species, estimated from the relative importance of each habitat variable to the species habitat requirements. Two habitat value scores were calculated for each species, one for the Proposed Disturbance Area and one for the Proposed Offset Areas. The scores are relative and do not have meaningful units, rather it is the comparison of the scores between the target areas that is important. For instance, the target area with the highest score provides higher quality habitat for the species than the lower scoring area.

It should be noted that this score is not a stand-alone measurement or assessment, it is simply a means of providing a comparison of the relative habitat value of these areas. Other factors (assessed elsewhere in this report) are also very important in determining the likely value of different areas to different species.

Habitat value analysis was undertaken on 14 individual threatened fauna species and two groups of micro-bats (split into hollow- and cave-dependent species) (**Table 3.11**).

Table 3.11 - Individual Groups of Species considered in the Habitat Value Assessment

Common Name	Scientific Name
barking owl	*Ninox connivens*
Brown treecreeper	*Climacteris picumnus victoriae*
diamond firetail	*Stagonopleura guttata*
turquoise parrot	*Neophema pulchella*
glossy black-cockatoo	*Calyptorhynchus lathami*
grey-crowned babbler	*Pomatostomus temporalis temporalis*
hooded robin	*Melanodryas cucullata cucullata*
masked owl	*Tyto novaehollandiae*
powerful owl	*Ninox strenua*
speckled warbler	*Pyrrholaemus sagittata*
Brush-tailed rock-wallaby	*Petrogale penicillata*
Koala	*Phascolarctos cinereus*
spotted-tailed quoll	*Dasyurus maculatus maculatus*
squirrel glider	*Petaurus norfolcensis*
Cave-dependent Bats	
eastern bentwing-bat	*Miniopterus schreibersii oceanensis*
eastern cave bat	*Vespadelus troughtoni*
large-eared pied bat	*Chalinolobus dwyeri*
Hollow-dependent Bats	
eastern false pipistrelle	*Falsistrellus tasmaniensis*
eastern freetail-bat	*Mormopterus norfolkensis*
greater broad-nosed bat	*Scoteanax rueppellii*

3.6.5 Large-footed Myotis Foraging Resource

The large-footed myotis (*Myotis adversus*) is dependent on areas of open water for foraging, and was thus not suitable to be assessed via the habitat value calculation (**Section 3.6.4**) as this was based on terrestrial habitat parameters. Hoye et al. (2003) developed a Foraging Resource formula specifically for the large-footed myotis, which follows:

$$\textbf{Large-footed myotis Foraging Resource} = \frac{A}{100} \times \left(\left(\frac{OW}{100} \right) + \left(0.5 \times \left(\frac{ELR}{100} \right) \right) \right)$$

Where:

A	=	Area of water body at 100% capacity in square metres
OW	=	Percentage of open water
ELR	=	Edge length of fringing reeds in metres

All water bodies encountered during the condition assessment field surveys (predominately farm dams) were sampled for large-footed myotis foraging resource value. At each water body the area of the water body at 100% capacity, percentage of open water and edge length of fringing reeds were assessed. **Appendix D** contains a copy of the proforma used for this assessment.

3.6.6 Hollow-bearing Tree Density

All trees present within each condition assessment quadrat were searched for the presence of hollows. When hollows were present, the size, orientation and location of each hollow was recorded. **Appendix C** contains a copy of the hollow-bearing tree proforma used, and lists the individual classes of hollow size, orientation and location. The DBH, height, percentage dead timber and tree species of each hollow-bearing tree were also recorded.

3.6.7 Koala Searches

Within 55 of the 85 condition assessment sites (**Figure 3.5**) a koala (*Phascolarctos cinereus*) scat search was completed around the base of the ten largest trees (as identified by DBH measurements). A one metre radius around the base of each selected tree was searched for a period of approximately one minute. All possible koala scats were collected for verification by Barbara Triggs (a recognised expert in the field) of Dead Finish, Victoria. When more than 10 large trees of approximately the same size occurred, eucalypt species were selected ahead of non-eucalypt species. A visual search of tree canopies was also undertaken while travelling between survey sites on foot or in vehicles. Seventy-five kilometres of visual canopy searches were undertaken (see **Figure 3.4**).

3.7 Aquatic Survey Effort

A survey of aquatic flora and fauna species, including a detailed habitat assessment and macroinvertebrate sampling, was undertaken in the Proposed Disturbance Area and part of the Proposed Offset Areas during November 2004. Initial site investigations were undertaken on 15 November 2004, with the majority of fieldwork undertaken in the period of 16 to 19 November 2004. Habitat assessment and macroinvertebrate sampling were conducted in Clarks Gully and Anvil Creek within the Proposed Disturbance Area and Big Flat Creek within the Proposed Offset Areas. In addition to this, sites in nearby Wybong Creek and Sandy Creek were sampled to enable a comparison with the Proposed

Disturbance Area (**Figure 3.6**). Habitat assessment was also undertaken in high order drainage lines within the northern sections of the Proposed Offset Areas.

Qualitative assessments of drainage lines within the remainder of the Proposed Offset Areas were undertaken at various times during the seven fauna surveys undertaken within this area between November 2004 and December 2005.

3.7.1 Literature Review

Prior to the fieldwork, a comprehensive literature review was undertaken to identify aquatic habitats and fauna species that have been previously recorded in the Hunter River catchment. Department of Primary Industries (NSW Fisheries) guidelines and general information regarding freshwater fish and invertebrates of south-eastern Australia were also reviewed.

In addition, current lists of threatened species and key threatening processes were sourced from the Department of Primary Industries (NSW Fisheries) and DEH websites. A review was then conducted of available information on threatened species and threatened fish habitats relevant to the Study Area.

3.7.2 Habitat Assessment

Preliminary mapping of the broad scale aquatic habitats within the Study Area was undertaken using recent aerial photography in conjunction with topographic maps prior to the field surveys. Topographic maps were used to gain a broad understanding of catchment characteristics including adjacent land use, elevation, access routes, distance from source and location of barriers to fish passage, such as dams and weirs.

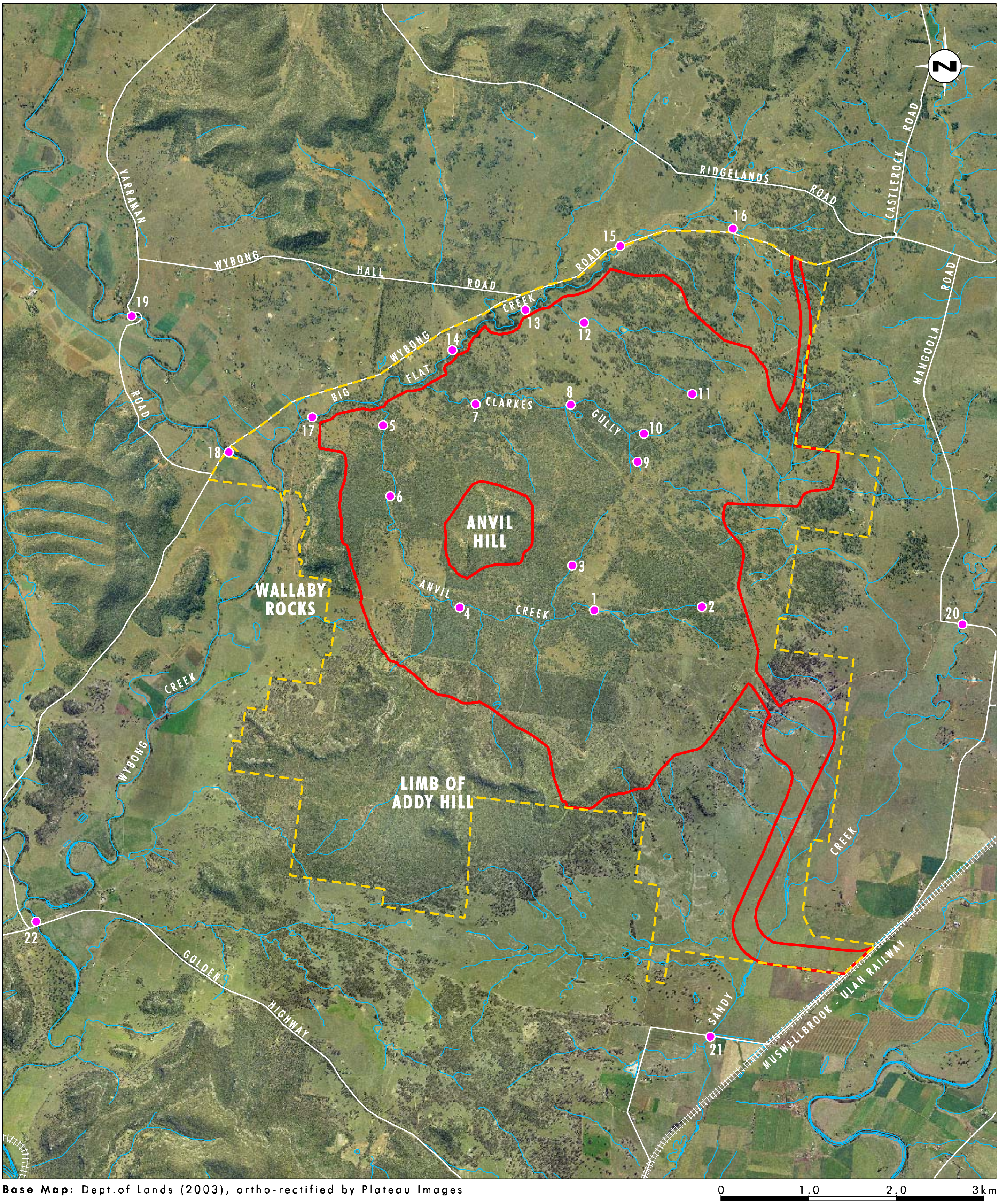
The field survey commenced with inspections of Anvil Creek, Big Flat Creek and Clarks Gully. Geomorphological characteristics and in-stream habitats were assessed qualitatively using field observations and photos. A qualitative assessment, using rapid assessment methods, of all potentially affected aquatic habitats in the Proposed Disturbance Area, as well as suitable aquatic habitat in the Proposed Offset Areas, was compiled from observations made during the surveys. The qualitative assessment included observations regarding characteristics such as potential fish habitat, presence of large woody debris, undercutting of banks, aquatic vegetation, riparian vegetation, shade cover, water clarity and water level. Physical characteristics, such as channel dimensions, bed load, bank stability and evidence of erosion were also assessed.

3.7.3 Aquatic Sampling

A quantitative assessment, in accordance with the Australian Rivers Assessment Scheme (AusRivAS) was not undertaken for this study due to a lack of suitable sampling habitat in both the Proposed Disturbance Area and Proposed Offset Areas. The AusRivAs NSW standardised sampling method is designed to target the two most common aquatic habitats (that is riffle and edge habitat), requiring a ten metre section of both habitats to be sampled per sampling site. The ephemeral nature of the creeks and drainage lines and low water levels at the time of the survey prevented the use of this assessment method. Low flows and lack of pool habitat also hindered the application of other quantitative assessment methods such as poddy trapping and dip netting, both of which require minimum water levels and channel dimensions.

3.7.3.1 Macroinvertebrate Sampling

Macroinvertebrate sampling was undertaken at sites 4, 6, 8, 11, 12, 13, 14, 17, 18, 19 and 22 (**Figure 3.6**). A hand held dip net was used to sample macroinvertebrates and small fish at



Base Map: Dept.of Lands (2003), ortho-rectified by Plateau Images

Legend

- Proposed Disturbance Area
- Study Area
- Water Courses
- Aquatic Sampling Sites

FIGURE 3.6

Aquatic Sampling Sites

all sampling sites. Dip netting was conducted using a 35 millimetre diameter and 250 µm mesh net. Samples were collected from riffle and edge habitats by dragging the net over a standard area (1 cubic metre), whilst disturbing the bed sediments or edge habitat in order to dislodge any associated fauna. Five replicate 1m^3 samples were collected from each site.

Macroinvertebrates were live-picked in the field and identified to the lowest practical taxonomic level (usually families) with the aid of a binocular microscope, and field guides *The Waterbug Book* (Gooderham & Tsyrlin 2002) and *Australian Freshwater Life* (Williams 2001). Identified macroinvertebrates were preserved in labelled jars with 70% ethanol.

Macroinvertebrate families were then awarded pollution sensitivity grades according to their level of tolerance/intolerance to common pollutants, based on the NSW Water Bug Survey classification system (Department of Land and Water Conservation 2000).

3.7.3.2 Vertebrate Sampling

Baited fish traps were used to sample vertebrate communities at sites where water depth permitted. Traps were baited with stale bread and placed in pool habitat adjacent to instream vegetation, overhanging vegetation or snags.

Aquatic vertebrates were sampled at sites 11, 14 and 17 (refer to **Figure 3.6**). Captured aquatic vertebrates were identified with the use of *Field Guide to the Freshwater Fishes of Australia* (Allen et al. 2002).

3.7.3.3 Aquatic Flora

A walking transect was undertaken at each sampling site to assess the presence and types of aquatic flora. These walking transects were conducted to determine species composition and community structure, such as whether the dominant vegetation was submerged, emergent or floating. Walking transects were also used to determine species composition and community structure of fringing riparian vegetation.

Samples of all unknown plant species were collected in the field, pressed and dried for later identification, and forwarded to the National Herbarium of New South Wales if necessary.

4.0 Flora Results

As a result of flora surveys and vegetation community mapping, a diverse range of plant species and vegetation communities, including threatened species, were recorded in the Study Area. The following sections detail these results, as well as the management history of vegetation in the Study Area.

4.1 Flora Species Recorded

In total, 597 plant species were recorded in the Study Area from all surveys. These comprised trees, tree mallees, shrubs, forbs, grasses, sedges, rushes, reeds, ferns, lithophytes, epiphytes, mistletoes, vines and twiners. Plants were recorded from all four major vascular plant classes: cycads, conifers, ferns and flowering plants (**Table 4.1**).

Table 4.1 - Composition of plant classes and families recorded

Plant class	Sub-class	Number of families	Number of species
Filicopsida (ferns)	-	5	11
Cycadopsida (cycads)	-	1	4
Coniferopsida (conifers)	-	1	1
Magnoliopsida (flowering plants)	Magnoliidae (dicots)	68	410
Magnoliopsida (flowering plants)	Liliidae (monocots)	19	171
Totals (all plants)		**94**	**597**

Ninety-four plant families were recorded (**Table 4.1**). Poaceae was the most speciose plant family, followed by Asteraceae and Fabaceae. **Table 4.2** shows the top ten most speciose families.

Table 4.2 - Ten most speciose plant families recorded within the Study Area

Family (common name)	Number of species
Poaceae (grasses)	99
Asteraceae (daisies)	70
Fabaceae (peas & wattles) – total	54
(Fabaceae – Faboideae)	(33)
(Fabaceae – Mimosoideae)	(21)
Myrtaceae (eucalypts, tea trees & paperbarks)	29
Cyperaceae (sedges)	17
Chenopodiaceae (chenopods)	17
Euphorbiaceae (euphorbs)	13
Orchidaceae (orchids)	12
Rubiaceae (bedstraws, woodruffs and canthiums)	11
Solanaceae (nightshades)	10
Total	**332**

The most speciose genera (**Table 4.3**) were dominated by *Acacia* and *Eucalyptus*, with 21 and 14 species respectively. Shrubby growth-forms dominated the most speciose genera, ahead of grasses, forbs and trees.

Table 4.3 - The twelve most speciose plant genera recorded within the Study Area

Genus (common name)	Number of species
Acacia (wattles)	21
Eucalyptus (eucalypts)	14
Aristida (wiregrasses)	13
Wahlenbergia (native bluebells)	9
Austrodanthonia (wallaby grasses)	8
Solanum (nightshades)	7
Eragrostis (lovegrasses)	7
Vittadinia (fuzzweeds)	6
Hibbertia (Guinea-flowers)	6
Cyperus (sedges)	6
Goodenia (goodenias)	6
Lomandra (mat-rushes)	6
Total taxa	**109**

Of the plants recorded, 95 (15.9%) were not native to the Study Area. Six noxious weed species (1% of the flora of the Study Area), as listed in the NSW Government Gazette No. 166, 23 December 2005 (New South Wales Government 2005), were recorded in the Study Area (**Table 4.4**). One of these, bridal creeper (*Asparagus asparagoides*), is also a *Weed of National Significance*, as listed by Thorp and Lynch (2000) under the Commonwealth Government's National Weeds Strategy 1997.

Table 4.4 - Noxious weeds and Weeds of National Significance recorded in the Study Area

Family	Botanical name	Common name	Noxious weed control objective	Weed of National Significance
Asparagaceae	*Asparagus asparagoides*	bridal creeper	5	Yes
Asteraceae	*Xanthium occidentale*	Noogoora burr	4	-
	Xanthium spinosum	Bathurst burr	4	-
Cactaceae	*Opuntia aurantiaca*	tiger pear	5	-
	Opuntia stricta var. *stricta*	prickly pear	5	-
Solanaceae	*Lycium ferocissimum*	African boxthorn	5	-

Notes: Control objectives:

4 Minimise the negative impact of those plants on the economy, community or environment of NSW.

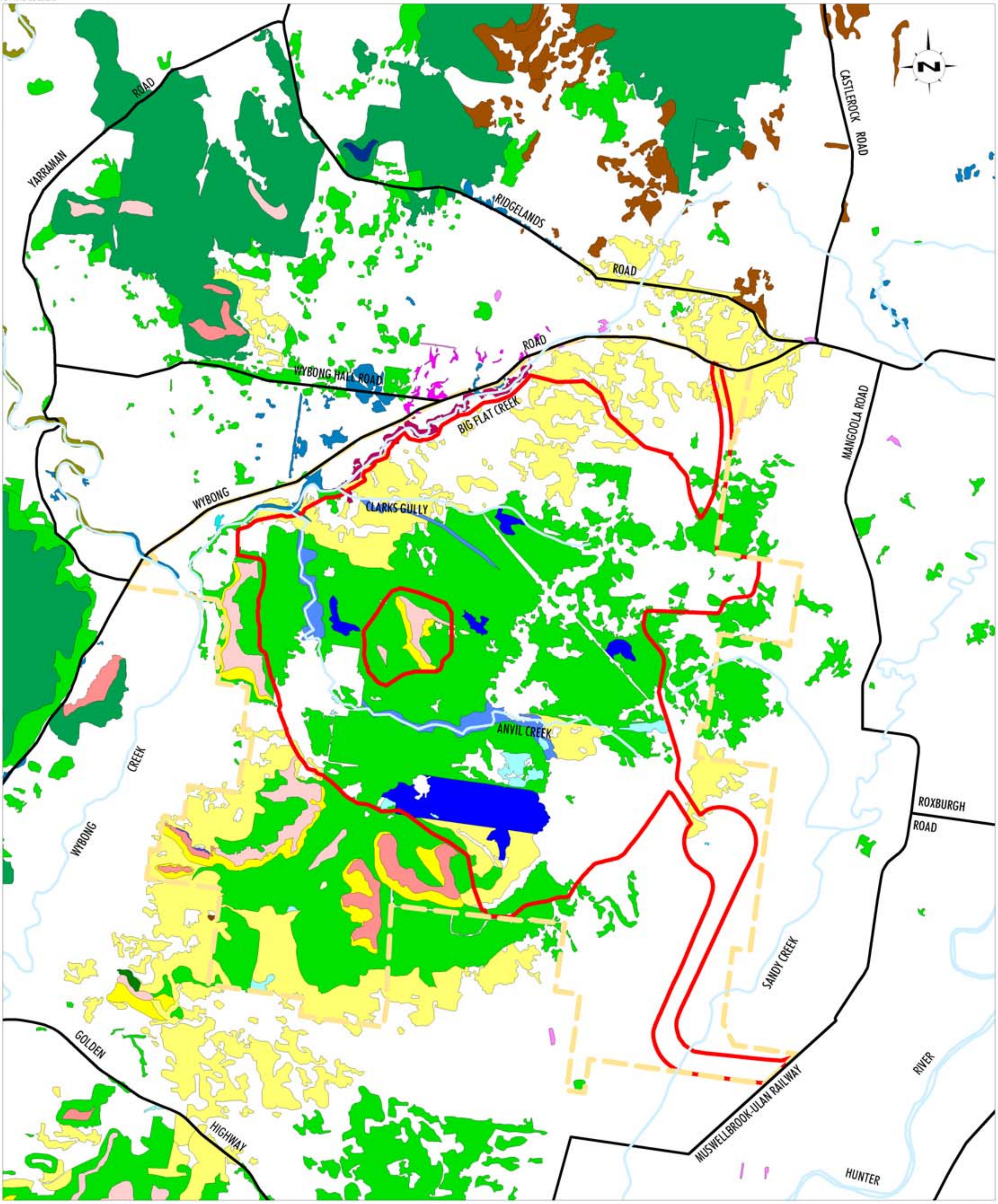
5 Prevent the introduction of those plants into NSW, the spread of those plants within NSW or from NSW to another jurisdiction.

* Denotes introduced – not native to Australia or the Study Area.

Three other significant weeds were also recorded: galenia (*Galenia pubescens*), Rhodes grass (*Chloris gayana*) and panic veldtgrass (*Ehrharta erecta*). These weeds are highly significant environmental weeds, with the potential to significantly modify the ecosystems that they invade (Peake 2006).

4.2 Vegetation Communities

Seventeen vegetation communities were recorded in the Study Area (**Table 4.5** and **Figure 4.1**). All except three are naturally-occurring, although most have been significantly modified during the past two centuries through extensive management, including clearing and regeneration.



Source: Peake (2006)

Legend

- Proposed Disturbance Area
- Study Area

- Slaty Box Woodland
- Ironbark Woodland Complex
- Bulloak Woodland
- Exotic Rushland
- Sheltered Grey Gum Woodland
- Weeping Myall Woodland
- Spotted Gum Open Forest
- Ironbark-Wattle Low Exposed Woodland Complex
- Red Ash Sheltered Forest
- Swamp Oak Riparian Forest
- Disturbed Grassland
- River Oak Riparian Forest
- Rough-barked Apple Woodland
- Tall Mixed Shrubland Complex
- Coast Myall Exposed Woodland
- Forest Red Gum Riparian Woodland
- Mixed Species Revegetation/ Plantation
- Drooping Sheoak Woodland
- Paperbark Woodland
- Cypress Pine Woodland
- Low Shrubland
- Currawang Tall Woodland

FIGURE 4.1

Vegetation Communities

Table 4.5 - Vegetation Communities and Formations of the Study Area

Vegetation Community	Proposed Disturbance Area (ha)	% within Proposed Disturbance Area	Proposed Offset Areas (ha)	% within Proposed Offset Area	Total Within Study Area (ha)
Woodland	**1251**	**59**	**874**	**41**	**2125**
Slaty Box Woodland	245	46	282	54	527
Ironbark Woodland Complex	886	64	507	36	1393
Bulloak Woodland	100	100	0.4	0.4	100
Sheltered Grey Gum Woodland	0.0	0.0	79	100	79
Red Ash Sheltered Forest	0.0	0.0	0.7	100	0.7
Drooping Sheoak Woodland	0.8	40	1	60	2
Mixed Species Revegetation/Plantation	0.0	0.0	0.8	100	0.8
Paperbark Woodland	19	83	3	17	23
Riparian and Floodplain	**53**	**63**	**31**	**37**	**84**
Exotic Rushland	0.0	0.0	0.2	100	0.2
Swamp Oak Riparian Forest	1.0	5	20	95	21
River Oak Riparian Forest	0.0	0.0	0.6	100	0.6
Rough-barked Apple Woodland	0.3	3	11	97	11
Forest Red Gum Riparian Woodland	51	100	0.0	0.0	51
Shrubland	**0.2**	**0.2**	**127**	**100**	**127**
Tall Mixed Shrubland Complex	0.0	0.0	52	100	52
Weeping Myall Woodland	0.1	10	0.9	90	1
Coast Myall Exposed Woodland	0.2	0.3	74	100	74
Grassland	**934**	**52**	**872**	**48**	**1806**
Disturbed Grassland	934	52	872	48	1806
TOTAL (ha)	**2238**		**1904**		**4142**

Most vegetation communities are widespread in the local area, while some occur much more extensively across a range of over 100 kilometres. Some communities, however, have a more restricted local occurrence, being known only to occur locally within the Study Area or within a short distance of the Study Area. In general, communities occurring on Triassic conglomerate are well represented in the local area, while those restricted to riparian zones (including floodplains) are less well represented. Communities occurring on Permian sediments are generally representative of the widespread but highly cleared woodlands of the central Hunter Valley, although Peake (2006) indicated that the vegetation of the Wybong Uplands area was of floristic interest, as it did not align completely with other vegetation, throughout the Hunter Valley floor, and required further investigation.

Vegetation communities were further grouped into vegetation formations (**Table 4.5** and **Figure 4.2**) for the purposes of additional analysis and impact assessment (see **Section 3.4** for the method). Four formations were recognised: Woodland; Riparian/Floodplain; Shrubland and Grassland. Most communities were allocated to the Woodland formation, while only one (Disturbed Grassland) comprised the Grassland formation. The balance comprised the Riparian/Floodplain and Shrubland formations. This grouping was undertaken primarily to determine the likely presence of threatened species habitat across the Study Area (see **Section 4.4**).

The following sub-sections provide the following information on each vegetation community:

- a floristic and structural description;
- the occurrence of each community in the Study Area in relation to the Proposed Disturbance Area and Proposed Offset Areas; and
- the degree of similarity with communities delineated by the Hunter Remnant Vegetation Project (Peake 2006), and the conservation status of the community.

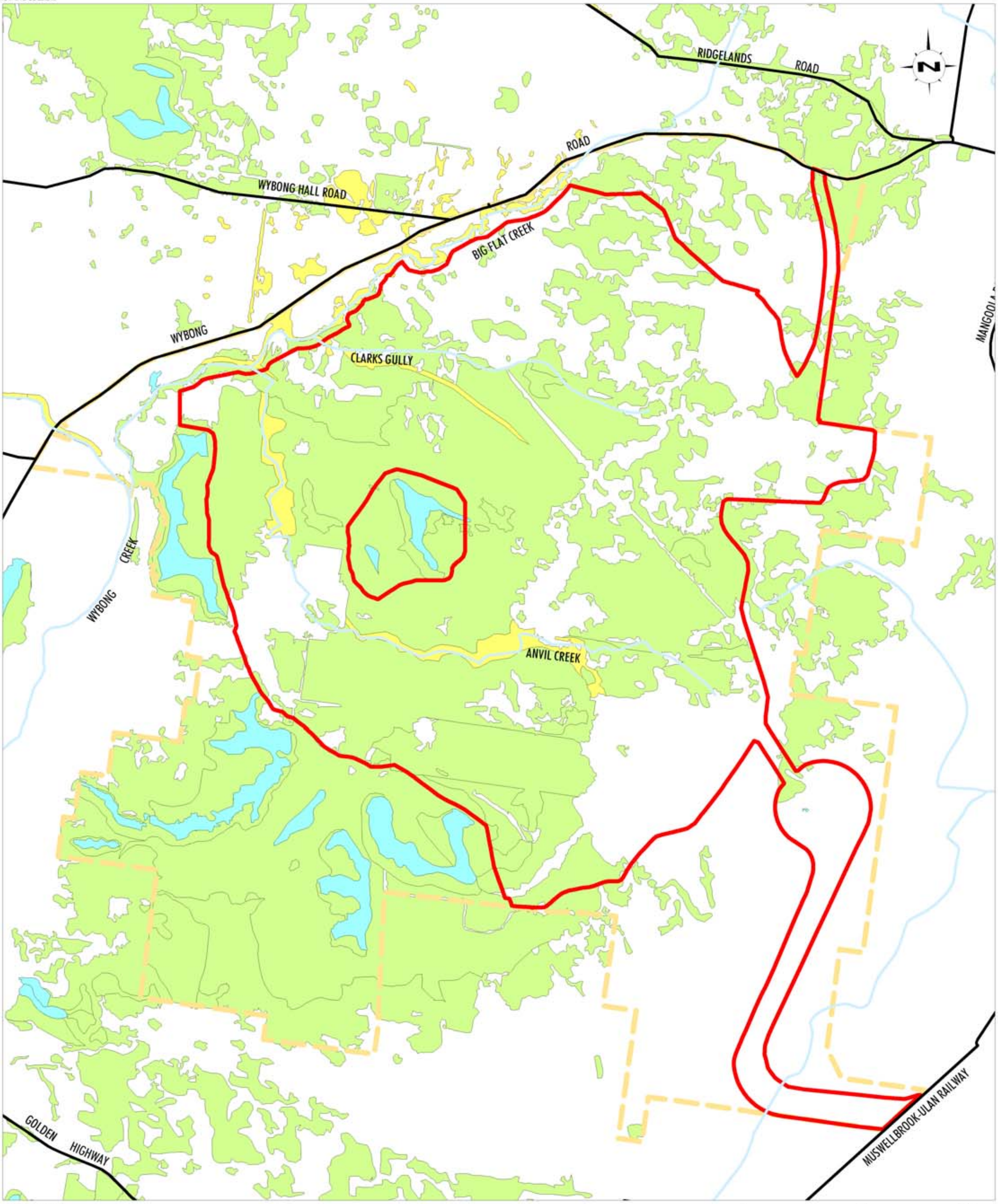
4.2.1 Vegetation Communities Occurring within the Study Area

4.2.1.1 Slaty Box Woodland

Slaty Box Woodland is a widespread and abundant vegetation community in the Study Area (**Table 4.5** and **Figure 4.1**). It is characterised by the predominance of slaty box (*Eucalyptus dawsonii*) throughout its range in the Study Area. It forms a woodland canopy of about 12-20 metres in height and 10-40% cover. In many areas, dense regeneration of slaty box occurs, in which the canopy cover may be higher. Other trees that occur infrequently, or occasionally in abundance, in this vegetation community include grey box (*Eucalyptus moluccana*) and narrow-leaved ironbark (*Eucalyptus crebra*). Bulloak (*Allocasuarina luehmannii*) often forms a sparse low tree layer of up to ten metres in height.

There is usually no consistent shrub layer present, although in places a 1-3 metre high layer of up to 30% cover may occur. Typical shrub species present include native olive (*Notelaea microcarpa* var. *microcarpa*), hop-bush (*Dodonaea viscosa* subsp. *mucronata* and subsp. *cuneata*), native broom (*Spartothamnella juncea*), gold dust wattle (*Acacia piligera*), western golden wattle (*Acacia decora*) and, in the south and north-west of the Study Area, Mudgee wattle (*Acacia spectabilis*). The weed African boxthorn (*Lycium ferocissimum*) occurs in moderate abundance in some areas.

The groundcover is typically sparse, varying between 30 and 50% with a height of typically less than 0.3 metre. Often, large expanses of bare soil or leaf and bark litter are present, with only sparse clumps of groundcover plants. It is suspected that this may inhibit the growth of groundcovers and shrubs, through smothering or allelopathy. Common species include poison rock fern (*Cheilanthes sieberi* subsp. *sieberi*), kidney weed (*Dichondra repens*), many-flowered mat-rush (*Lomandra multiflora* subsp. *multiflora*), wire grass (*Aristida ramosa*), blue trumpet (*Brunoniella australis*), barbed wire grass (*Cymbopogon refractus*),



Source:

Legend

- Proposed Disturbance Area
- Study Area
- Riparian / Floodplain
- Shrubland
- Woodland
- Grassland

FIGURE 4.2

Vegetation Formations and Fauna Habitat Types

large tick-trefoil (*Desmodium brachypodum*), winter apple (*Eremophila debilis*), common fringe-rush (*Fimbristylis dichotoma*) and spurge (*Phyllanthus virgatus*), and the weeds tiger pear (*Opuntia aurantiaca*) and prickly pear (*Opuntia stricta* var. *stricta*).

Mistletoes are frequent, particularly in highly fragmented areas, with the most common being box mistletoe (*Amyema miquelli*) and drooping mistletoe (*Amyema pendulum* subsp. *pendulum*). The epiphytic tiger orchid (*Cymbidium canaliculatum*) is a rare inhabitant of all three canopy tree species. Vines are infrequent.

This community is broadly similar to MU 7 Narrabeen Footslopes Slaty Box Woodland of the Hunter Remnant Vegetation Project, however those areas in the Study Area where it occurs were mapped as MU 10 Central Hunter Box – Ironbark Woodland, as an agglomerative cluster analysis showed that at the regional level sites surveyed in the Wybong district were more closely affiliated with that community (Peake 2006). Regardless of which of the two communities that it corresponds with, Peake (2006) regarded both to meet the DEH (2006) listing criteria and to be regionally significant.

Slaty Box Woodland covers 527 hectares of the Study Area (**Table 4.5**), with 47% of the total area occurring within the Proposed Disturbance Area and 54% in the Proposed Offset Areas. It occurs in two main areas: in the north it is present as highly fragmented remnants, while in the south and south-west it occurs as a contiguous band of vegetation adjacent to Ironbark Woodland Complex (**Figure 4.1**). There are two other occurrences of it in the eastern parts of the Study Area. This community is moderately widespread in the local area. Peake (2006) considers its level of reservation to be low to moderate.

4.2.1.2 Ironbark Woodland Complex

Ironbark Woodland Complex is the most widespread natural vegetation community in the Study Area (**Table 4.5** and **Figure 4.1**). It is a highly variable community, both in terms of its structure and floristic composition, that is characterised by the more or less ubiquitous presence of narrow-leaved ironbark (*Eucalyptus crebra*). It typically forms a canopy that has 10-40% cover and ranges between 10 and 25 metres in height. It often forms associations with several other canopy trees, including grey box (*Eucalyptus moluccana*), Blakely's red gum (*Eucalyptus blakelyi*), rough-barked apple (*Angophora floribunda*) and kurrajong (*Brachychiton populneus* subsp. *populneus*). Bulloak (*Allocasuarina luehmannii*), drooping sheoak (*Allocasuarina verticillata*) or black cypress pine (*Callitris endlicheri*) may form a sparse to occasionally dense mid-understorey in many areas.

The understorey is highly variable, and may range from 10-50% cover or be absent. Heights range from 1.5 to 4 metres. Dominant species include native olive (*Notelaea microcarpa* var. *microcarpa*), silver-stemmed wattle (*Acacia filicifolia*), gold dust wattle (*Acacia piligera*), native broom (*Spartothamnella juncea*), five corners (*Styphelia triflora*), native blackthorn (*Bursaria spinosa* subsp. *spinosa*), hickory wattle (*Acacia falcata*), iamboto (*Psydrax odorata*), coffee bush (*Breynia oblongifolia*), cough bush (*Cassinia cunninghamii*), hop bush (*Dodonaea viscosa* subsp. *mucronata* and subsp. *cuneata*), water bush (*Myoporum montanum*) and the weed African boxthorn (*Lycium ferocissimum*). Due to the community's highly variable nature a wide range of shrub species may be present. Mountain grevillea (*Grevillea montana*) is a consistent understorey species in much of the potential southern offset area. Subshrubs are common and may include hoary Guinea flower (*Hibbertia obtusifolia*), prickly Guinea flower (*Hibbertia acicularis*), Narrawa burr (*Solanum cinereum*), violet nightshade (*Solanum brownii*), spurge (*Phyllanthus virgatus*), Indian weed (*Sigesbeckia orientalis* subsp. *orientalis*), eastern cotton bush (*Maireana microphylla*) and several others.

The groundcover varies from sparse to dense, and is typically less than 0.3 metre in height. It comprises a large variety of forbs, many grasses, and a small number of sedges, ferns and twiners. The more abundant species include barbed wire grass (*Cymbopogon refractus*), threeawned wire grass (*Aristida ramosa*), kidney weed (*Dichondra repens*), wallaby grass

(*Austrodanthonia fulva*), poison rock fern (*Cheilanthes sieberi* subsp. *sieberi*), tall chloris (*Chloris ventricosa*), corkscrew grass (*Austrostipa scabra*), slender tick-trefoil (*Desmodium varians*), slender wire lily (*Laxmannia gracilis*), weeping grass (*Microlaena stipoides* var. *stipoides*), purple lovegrass (*Eragrostis lacunaria*), paddock lovegrass (*Eragrostis leptostachya*), slender rat's tail grass (*Sporobolus creber*), yellow burr-daisy (*Calotis lappulacea*), many-flowered mat-rush (*Lomandra multiflora* subsp. *multiflora*), blue trumpet (*Brunoniella australis*), winter amulla (*Eremophila debilis*), bristly cloak fern (*Cheilanthes distans*), common everlasting (*Chrysocephalum apiculatum*), *Cyperus gracilis*, climbing saltbush (*Einadia nutans*), austral bugle (*Ajuga australis*), fuzzweed (*Vittadinia cuneata*), variable glycine (*Glycine tabacina*), fishweed (*Einadia trigonos*), and corrugated sida (*Sida corrugata*). Common weeds include Paddy's lucerne (*Sida rhombifolia*), tiger pear (*Opuntia aurantiaca*), prickly pear (*Opuntia sricta* var. *stricta*), flatweed (*Hypochaeris radicata*) and tall fleabane (*Conyza sumatrensis*).

A small number of vines may be present, including traveller's joy (*Clematis glycinoides* var. *glycinoides*), wombat berry (*Eustrephus latifolius*) and wonga vine (*Pandorea pandorana* subsp. *pandorana*). Mistletoes are usually present, and usually include box mistletoe (*Amyema miquelli*), drooping mistletoe (*Amyema pendulum* subsp. *pendulum*), kurrajong mistletoe (*Notothixos cornifolius*) and sheoak mistletoe (*Amyema cambagei*). While rare, the epiphytic tiger orchid (*Cymbidium canaliculatum*) is at its most abundant in Ironbark Woodland Complex.

This community is broadly similar to MU 10 Central Hunter Box – Ironbark Woodland of the Hunter Remnant Vegetation Project, however those areas in the Study Area where it occurs were mapped as MU 10, which Peake (2006) assessed as meeting the DEH (2006) listing criteria and to be regionally significant.

Ironbark Woodland Complex is the most widespread natural vegetation community in the Study Area, covering 1393 hectares (**Table 4.5**). It dominates the central and southern parts of the Study Area (**Figure 4.1**). The Proposed Disturbance Area is occupied by 64% of the total area of this community in the Study Area, with 36% occurring in the Proposed Offset Areas. This community is common and widespread in the local area and throughout the central Hunter Valley. Peake (2006) considers its level of reservation to be very poor.

4.2.1.3 Bulloak Woodland

Bulloak Woodland, a highly restricted vegetation community in the Study Area (**Table 4.5** and **Figure 4.1**), is characterised entirely by the presence of bulloak (*Allocasuarina luehmannii*), which usually attains a height of 6-12 metres and a density of 30-60%. Dense stands of bulloak occur apparently largely as a result of land management practices. Peake (2006) suggested that bulloak appears to establish well on pasture that has had grazing pressure removed for a number of years. In this way the species becomes well established, but may simply signify a successional stage in the development of a more structurally and floristically complex community, such as Ironbark Woodland Complex.

Other trees that occur sparsely in this community include narrow-leaved ironbark (*Eucalyptus crebra*), grey box (*Eucalyptus blakelyi*), slaty box (*Eucalyptus dawsonii*) and Blakely's red gum (*Eucalyptus blakelyi*). Typically no mid-understorey or understorey strata are present, although juvenile bulloak may form these strata in places.

The groundcover is usually very sparse and less than 0.3 metre in height, being inhibited by the presence of a high abundance of fallen branchlets. Grasses are typically sparse tussocks and may include the following species: threeawn speargrass (*Aristida vagans*), couch (*Cynodon dactylon*), paddock lovegrass (*Eragrostis leptostachya*), slender bamboo grass (*Austrostipa verticillata*), barbed wire grass (*Cymbopogon refractus*), hairy panic (*Panicum effusum*) and threeawn grass (*Aristida ramosa*). Forbs, sedges and ferns are usually sparse and may include common fringe-rush (*Fimbristylis dichotoma*), scurvy weed (*Commelina cyanea*), slender wire lily (*Laxmannia gracilis*), many-flowered mat-rush (*Lomandra multiflora* subsp. *multiflora*), poison rock fern (*Cheilanthes sieberi* subsp. *sieberi*), bristly cloak fern (*Cheilanthes distans*), common everlasting (*Chrysocephalum apiculatum*), fishweed (*Einadia trigonos*), *Cyperus* spp., berry saltbush (*Einadia hastata*), variable glycine (*Glycine tabacina*), ivy goodenia (*Goodenia hederacea* subsp. *hederacea*) and wattle mat-rush (*Lomandra filiformis*).

The aerial hemiparasitic shrub sheoak mistletoe (*Amyema cambagei*) is also often present. Vines are usually absent.

This community is equivalent to MU 32 Central Hunter Bulloak Regeneration of the Hunter Remnant Vegetation Project, which Peake (2006) assessed as meeting the DEH (2006) listing criteria.

Bulloak Woodland occurs in five locations covering 100 hectares within the Study Area (**Table 4.5**), with all except 0.4 hectare being located within the Proposed Disturbance Area (**Figure 4.1**). Because this community is difficult to separate from Ironbark Woodland Complex, and to a lesser extent Slaty Box Woodland, it is likely that more occurrences of this community are present in both the Proposed Disturbance Area and the Proposed Offset Areas.

The most extensive occurrence of this community (about 80 hectares) is in the southern part of the Proposed Disturbance Area. Here the boundary of the community largely follows property boundary fence lines. Its occurrence here is likely to be, more so than in other areas, as a result of historical land management practices.

This community is common and widespread in the local area. Peake (2006) suggests that this community is unlikely to be reserved.

4.2.1.4 Sheltered Grey Gum Woodland

Sheltered Grey Gum Woodland is a highly restricted vegetation community in the Study Area (**Table 4.5** and **Figure 4.1**). This community is a woodland or sometimes open forest of 20-40% cover, and is dominated by grey gum (*Eucalyptus punctata*) which typically achieves a height of 12-25 metres. Other tree species that sometimes occur include narrow-leaved ironbark (*Eucalyptus crebra*), Blakely's red gum (*Eucalyptus blakelyi*), slaty box (*Eucalyptus dawsonii*) and kurrajong (*Brachychiton populneus* subsp. *populneus*).

A sparse to moderately dense mid-understorey layer is often present, with trees and tall shrubs attaining a height of 6-10 metres. Common species include red ash (*Alphitonia excelsa*), native olive (*Notelaea microcarpa* var. *microcarpa*) and kurrajong (*Brachychiton populneus* subsp. *populneus*). Black cypress pine (*Callitris endlicheri*) often occurs in more exposed, rocky locations, while ironwood (*Backhousia myrtifolia*) occurs in the more sheltered areas, particularly in well-defined gullies. Sweet pittosporum (*Pittosporum undulatum*) and native cherry (*Exocarpos cupressiformis*) also occur infrequently.

The shrub layer is sometimes sparse but usually dense, with up to 60% cover and a height of 2-4 metres. Common species include native blackthorn (*Bursaria spinosa* subsp. *spinosa*), native olive, coffee bush (*Breynia oblongifolia*), hop bush (*Dodonaea viscosa* subsp. *mucronata* and subsp. *cuneata*), narrow-leaved geebung (*Persoonia linearis*), sour bush (*Choretrum* species A), cough bush (*Cassinia cunninghamii*) and, in areas of colluvial soil accumulation, silver-stemmed wattle (*Acacia parvipinnula*). Several species of sub-shrubs may be common, including urn heath (*Melichrus urceolatus*), thyme spurge (*Phyllanthus hirtellus*), nightshade (*Solanum campanulatum*) and hoary Guinea flower (*Hibbertia obtusifolia*).

The groundcover is typically sparse, but may be moderately dense in some less rocky areas, and is usually less than 0.3 metre in height. Common species include mat-rush (*Lomandra confertifolia*), pomax (*Pomax umbellata*), blue flax lillies (*Dianella revoluta* var. *revoluta* and

D. caerulea), *Cleistochloa rigida*, wiry panic (*Entolasia stricta*), wire grass (*Aristida ramosa*), finger grass (*Digitaria ramularis*), variable saw-sedge (*Lepidosperma laterale*) and poison rock fern (*Cheilanthes sieberi* subsp. *sieberi*), while the cycad *Macrozamia reducta* is moderately common.

Mistletoes are uncommon, however the rare epiphytic tiger orchid (*Cymbidium canaliculatum*) occurs on occasion. Weeds are usually uncommon.

This community is equivalent to MU 15 Western Hunter Narrabeen Exposed Grey Gum – Stringybark Woodland of the Hunter Remnant Vegetation Project, which Peake (2006) indicated did not meet the DEH (2006) listing criteria.

Sheltered Grey Gum Woodland is restricted to the southern and south-western footslopes of conglomerate escarpments (**Figure 4.1**), and occurs in eight locations, all within the Proposed Offset Areas. It covers 79 hectares (**Table 4.5**), with the most extensive occurrences being around Anvil Hill, Wallaby Rocks, Limb of Addy Hill and the Western Rocks. It is fairly widespread in the local area. Peake (2006) considers its level of reservation to be good.

4.2.1.5 Red Ash Sheltered Forest

Red Ash Sheltered Forest, a highly restricted community occurring only in two locations in the Proposed Offset Areas (**Table 4.5** and **Figure 4.1**), is characterised by an abundance of the low tree red ash (*Alphitonia excelsa*) growing at the footslopes of conglomerate escarpments. Typically a mid-dense to dense (40-70%) stratum of 6-14 metres height occurs in a narrow band at the base of escarpments. Other trees that may be present include grey gum (*Eucalyptus punctata*) and narrow-leaved ironbark (*Eucalyptus crebra*). Sweet pittosporum (*Pittosporum undulatum*) and black cypress pine (*Callitris endlicheri*) may also occur infrequently.

The understorey is generally sparse, as light levels are typically low. Shrubs that occur include native olive (*Notelaea microcarpa* var. *microcarpa*), native blackthorn (*Bursaria spinosa* subsp. *spinosa*) and native broom (*Spartothamnella juncea*). Sub-shrubs such as violet nightshade (*Solanum brownii*), Indian weed (*Sigesbeckia orientalis* subsp. *orientalis*) and spurge (*Phyllanthus virgatus*) are present.

The groundcover is typically sparse, being dominated mostly by forbs and grasses of less than 0.3 metre height and 30-80% cover. Common species include weeping grass (*Microlaena stipoides* var. *stipoides*), wallaby grass (*Austrodanthonia fulva*), couch (*Cynodon dactylon*), kidney weed (*Dichondra repens*), blue trumpet (*Brunoniella australis*) and the weeds tall fleabane (*Conyza sumatrensis*), prickly pear (*Opuntia stricta* var. *stricta*) and spear thistle (*Cirsium vulgare*).

This community is similar to Grey Gum Sheltered Woodland, except that red ash has become clearly dominant to the general exclusion of other tree or low tree species. It is most similar to MU 15 Western Hunter Narrabeen Exposed Grey Gum – Stringybark Woodland of the Hunter Remnant Vegetation Project, which Peake (2006) indicated did not meet the DEH (2006) listing criteria.

Red Ash Sheltered Forest is restricted to two very small (0.7 hectare in total, **Table 4.5**) occurrences along one escarpment in the southern Proposed Offset Areas (**Figure 4.1**). It is fairly widespread, although restricted in patch size, in the local area, and is likely to be well reserved.

4.2.1.6 Drooping Sheoak Woodland

Drooping Sheoak Woodland occurs in four discrete locations within the Study Area (**Table 4.5** and **Figure 4.1**). It is characterised solely by the presence of drooping sheoak

(*Allocasuarina verticillata*), which forms a low to mid-high (6-12 metres) woodland to open forest (20-50% cover). Other tree species are infrequent, except for narrow-leaved ironbark (*Eucalyptus crebra*), which can be co-dominant at some sites. Shrubs are usually sparse to very sparse, with the most frequent being native olive (*Notelaea microcarpa* var. *microcarpa*) and water bush (*Myoporum montanum*), while native broom (*Spartothamnella juncea*) may occur very sparsely as a sub-shrub.

The groundcover is typically sparse (30-50% cover) and low (less than 0.3 metre), and is usually suppressed by the high abundance of cladodes (leaves) dropped by the drooping sheoak. The most abundant species are finger grass (*Digitaria ramularis*), poison rock fern (*Cheilanthes sieberi* subsp. *sieberi*), wiry panic (*Entolasia stricta*), kidney weed (*Dichondra repens*) and couch (*Cynodon dactylon*). Prickly pear (*Opuntia stricta* var. *stricta*), tiger pear (*Opuntia aurantiaca*) and fireweed (*Senecio madagascariensis*) are the most abundant weeds. Vines are rare or absent. The sheoak mistletoe (*Amyema cambagei*) occurs frequently at some sites.

This community is not equivalent to any of the communities mapped by the Hunter Remnant Vegetation Project (Peake 2006).

Drooping Sheoak Woodland is restricted to 1 hectare within the Proposed Offset Areas and 0.8 hectare within the Proposed Disturbance Area (**Figure 4.1**). It occurs predominantly on the eastern spur extending from the Anvil Hill complex, as well as to the west of Limb of Addy. This community is interspersed with the Ironbark Woodland Complex. Drooping sheoak, which through its presence defines the community, frequently occurs as a mid-understorey in Ironbark Woodland Complex around the lower slopes of the Anvil Hill complex, Wallaby Rocks, and the Western Rocks. However, only in the few areas detailed above does it occur in such density to the exclusion of other trees that it has been able to be mapped as a separate community.

Drooping sheoak is fairly widespread in the local area. It is likely that it is well represented in local conservation reserves.

4.2.1.7 Mixed Species Revegetation/Plantation

This vegetation community comprises any areas that have been planted with native trees or shrubs (**Table 4.5** and **Figure 4.1**). Less than one hectare occurs in the Study Area, however several more hectares of planted natives occur within the local area.

This community is not of conservation significance.

4.2.1.8 Paperbark Woodland

Paperbark Woodland is a widespread community that occurs in semi-discrete locations in the Study Area (**Table 4.5** and **Figure 4.1**). It is characterised by the presence of white feather honeymyrtle (*Melaleuca decora*), which is a low tree that forms a low to mid-high canopy (6-12 metres) that is usually dense but can be fairly sparse (20-60% cover). It is infrequently associated with slaty box (*Eucalyptus dawsonii*), forest red gum (*Eucalyptus tereticornis*), Blakely's red gum (*Eucalyptus blakelyi*) and narrow-leaved ironbark (*Eucalyptus crebra*).

Shrubs are usually sparse or absent. The most frequent ones that do occur include native olive (*Notelaea microcarpa* var. *microcarpa*) and native broom (*Spartothamnella juncea*).

A sparse to mid-dense (30-60% cover) groundcover is present, usually less than 0.3 metre in height. The groundcover is highly variable, and is strongly influenced by the surrounding vegetation. Common species include weeping grass (*Microlaena stipoides* var. *stipoides*), poison rock fern (*Cheilanthes sieberi* subsp. *sieberi*), kidney weed (*Dichondra repens*), twining glycine (*Glycine clandestina*), blue trumpet (*Brunoniella australis*), Brown's lovegrass

(*Eragrostis brownii*), common fringe-rush (*Fimbristylis dichotoma*), wallaby grass (*Austrodanthonia fulva*) and three-awned wiregrass (*Aristida ramosa*).

The aerial hemiparasitic shrub, paperbark mistletoe (*Amyema gaudichaudii*) is very abundant, growing in white feather honeymyrtle.

Weeds are usually rare, although prickly pear (*Opuntia stricta* var. *stricta*) can occur in low abundance.

This community is equivalent to MU 17 Central Hunter Paperbark Soaks Woodland of the Hunter Remnant Vegetation Project, which Peake (2006) indicated may meet the DEH (2006) criteria for listing as an EEC. Peake (2006) noted that insufficient systematic sampling had been carried out in this community, and that more should be undertaken to determine its conservation significance.

Paperbark Woodland has been mapped in six locations (comprising 19 hectares) in the Proposed Disturbance Area and in two locations (comprising 3 hectares) in the southern Proposed Offset Areas (**Figure 4.1**). The most extensive occurrences are located in the south-eastern part of the Proposed Disturbance Area. This community is widely interspersed with the Ironbark Woodland Complex. White feather honeymyrtle, which through its presence defines the community, frequently occurs as a mid-understorey in Ironbark Woodland Complex in moist soak areas in both the Proposed Disturbance Area and the Proposed Offset Areas. However, only in the few areas detailed above does it occur in such density to the exclusion of other trees that it has been able to be mapped as a separate community.

Peake (2006) notes that this community occurs broadly between Sandy Hollow and Wybong east to Branxton. It is unlikely to be represented in conservation reserves.

4.2.1.9 Exotic Rushland

Exotic rushland, a highly restricted vegetation community in the Study Area (**Table 4.5** and **Figure 4.1**), is a non-native vegetation community that is characterised solely by the dominance of sharp rush (*Juncus acutus* subsp. *acutus*). This exotic weedy species forms mono-specific stands along waterways and drainage lines in the far northern part of the Study Area, and occurs moderately extensively in the local area proximate to Wybong Road. It forms a dense to very dense layer about one metre in height that excludes most other sub-shrubs. It occurs preferentially in saline areas.

This community is not of conservation significance.

Exotic Rushland covers 0.2 hectare of the Study Area (**Table 4.5**), exclusively within the Proposed Offset Areas, around the northern boundary of the Study Area along Big Flat Creek (**Figure 4.1**). It is gradually increasing its range in the local area through its invasion of other riparian areas. Small occurrences along Anvil Creek were not large enough to map as separate entities.

4.2.1.10 Swamp Oak Riparian Forest

Swamp Oak Riparian Forest occurs along Big Flat Creek predominantly within the Proposed Offset Areas (**Table 4.5** and **Figure 4.1**). It is characterised by the predominance of swamp oak (*Casuarina glauca*), which forms a low to mid-high (10-20 metres) open to closed forest (50-90% cover). Trees such as forest red gum (*Eucalyptus tereticornis*), Blakely's red gum (*Eucalyptus blakelyi*) and slaty box (*Eucalyptus dawsonii*) may occur infrequently. No mid-understorey is usually present.

A sparse shrub layer is often present, up to 3-4 metres in height. Common species include coffee bush (*Breynia oblongifolia*), native blackthorn (*Bursaria spinosa* subsp. *spinosa*), native broom (*Spartothamnella juncea*) and tree violet (*Hymenanthera dentata*). The weed African boxthorn (*Lycium ferocissimum*) occurs frequently in this community.

The groundcover in this community is typically less than 0.3 metre in height and is sparse to mid-dense (20-60% cover). Common species include kidney weed (*Dichondra repens*), weeping grass (*Microlaena stipoides* var. *stipoides*), slender bamboo grass (*Austrostipa verticillata*), common couch (*Cynodon dactylon*), whiteroot (*Pratia purpurascens*), variable glycine (*Glycine tabacina*), scurvy weed (*Commelina cyanea*), blue trumpet (*Brunoniella australis*) and poison rock fern (*Cheilanthes sieberi* subsp. *sieberi*). Common weeds include panic veldtgrass (*Ehrharta erecta*), kikuyu grass (*Pennisetum clandestinum*) and prairie grass (*Bromus cartharticus*).

Climbers may be uncommon or common, with species including traveller's joy (*Clematis glycinoides* var. *glycinoides*) and wonga vine (*Pandorea pandorana* subsp. *pandorana*).

Along and within streams water ribbons (*Triglochin procerum*) is the most common herb. The highly invasive weed sharp rush (*Juncus acutus* subsp. *acutus*) has been spreading in this community for a number of years and now forms significant stands in many areas.

This community is equivalent to MU 28 Central Hunter Swamp Oak Forest of the Hunter Remnant Vegetation Project, which Peake (2006) indicated met the DEH (2006) criteria for listing as critically endangered, and to be regionally significant.

Swamp Oak Riparian Forest is restricted Big Flat Creek, with 95% of the total recorded area in the Study Area being located in the Proposed Offset Areas (**Figure 4.1**), where it covers 20 hectares (**Table 4.5**). It is not very widespread in the local area, with the most important occurrences being those along Big Flat Creek. It typically occurs along more saline creeks. Peake (2006) considers its level of reservation to be extremely poor.

4.2.1.11 River Oak Riparian Forest

River Oak Riparian Forest is restricted to a very small occurrence along Wybong Creek, where a 0.6 hectare stand occurs just within the Study Area boundary (**Table 4.5** and **Figure 4.1**). It is characterised by the dominance of river oak (*Casuarina cunninghamiana* subsp. *cunninghamiana*), which may occasionally occur with forest red gum (*Eucalyptus tereticornis*) or rough-barked apple (*Angophora floribunda*), and forms a canopy that is tall (15-25 metres) and open (20-50% cover). No mid-understorey typically occurs, and shrubs are normally restricted to occasional weeds or relatively few natives. African boxthorn (*Lycium ferocissimum*) is often present.

The groundcover is dominated by a wide variety of native and introduced species. Native species include weeping grass (*Microlaena stipoides* var. *stipoides*), couch (*Cynodon dactylon*), basket grass (*Oplismenus aemulus*), stinging nettle (*Urtica incisa*), kidney weed (*Dichondra repens*), slender knotweed (*Persicaria decipiens*), whiteroot (*Pratia purpurascens*), native geranium (*Geranium solanderi* var. *solanderi*) and spiny-headed mat-rush (*Lomandra longifolia*). Common introduced species include kikuyu (*Pennisetum clandestinum*), panic veldtgrass (*Ehrharta erecta*), wandering Jew (*Tradescantia fluminensis*), paspalum (*Paspalum dilatatum*) and shivery grass (*Briza minor*).

Vines are common and include wonga wonga vine (*Pandorea pandorana* subsp. *pandorana*), traveller's joy (*Clematis glycinoides* var. *glycinoides*) and wombat berry (*Eustrephus latifolius*). The highly invasive weed balloon vine (*Cardiospermum grandiflorum*) is commonly established and dominant in many local occurrences of River Oak Riparian Forest. Sheoak mistletoe (*Amyema cambagei*) is a frequent aerial hemiparasite of river oak.

This community is equivalent to MU 30 Hunter Valley River Oak Forest of the Hunter Remnant Vegetation Project, which Peake (2006) indicated met the DEH (2006) criteria for listing as critically endangered and as regionally significant.

River Oak Riparian Forest is restricted Wybong Creek, occurring only as a small remnant (0.6 hectare, **Table 4.5**) within the Proposed Offset Areas, to the west of Wallaby Rocks (**Figure 4.1**). Other small occurrences are likely along Wybong Creek to the north-west of the Study Area. It typically occurs along riparian areas with lower salinity levels than those where swamp oak (*Casuarina glauca*) occurs. Peake (2006) considers its level of reservation to be extremely poor.

4.2.1.12 Rough-barked Apple Woodland

Rough-barked Apple Woodland occurs along creek flats within the Study Area (**Table 4.5** and **Figure 4.1**). It is dominated by rough-barked apple (*Angophora floribunda*), with forest red gum (*Eucalyptus tereticornis*), Blakely's red gum (*Eucalyptus blakelyi*) and slaty box (*Eucalyptus dawsonii*) occurring infrequently. Swamp oak (*Casuarina glauca*) and western grey box (*Eucalyptus microcarpa*) also occur rarely. An open to mid-dense canopy is present, usually 10-40% cover and 10-20 metres height. Mid-understorey trees are rare, except where swamp oak occurs.

Shrubs may be sparse to absent, and usually form an open layer of 1-3 metres in height. Common species include native olive (*Notelaea microcarpa* var. *microcarpa*), native blackthorn (*Bursaria spinosa* subsp. *spinosa*), coffee bush (*Breynia oblongifolia*) and hop-bush (*Dodonaea viscosa*). Sharp rush (*Juncus acutus* subsp. *acutus*) and African boxthorn (*Lycium ferocissimum*) are weeds that may both be abundant in places.

The groundcover is dense (70-95% cover) and usually less than 0.5 metre in height. It comprises a high diversity of native groundcovers, including weeping grass (*Microlaena stipoides* var. *stipoides*), kidney weed (*Dichondra repens*), tall sedge (*Carex appressa*), couch (*Cynodon dactylon*), spiny-headed mat-rush (*Lomandra longifolia*), common rush (*Juncus usitatus*), poison rock fern (*Cheilanthes sieberi* subsp. *sieberi*), scurvy weed (*Commelina cyanea*), knob sedge (*Carex inversa*), native geranium (*Geranium solanderi* var. *solanderi*), forest hedgehog grass (*Echinopogon ovatus*), swamp dock (*Rumex brownii*), ivy-leaved violet (*Viola hederacea*) and wood sorrel (*Oxalis exilis*). Introduced groundcovers are common and include kikuyu (*Pennisetum clandestinum*), shivery grass (*Briza minor*), fireweed (*Senecio madagascariensis*), flatweed (*Hypochaeris radicata*), common sowthistle (*Sonchus oleraceus*), *Facelis retusa*, tall fleabane (*Conyza sumatrensis*), Paddy's lucerne (*Sida rhombifolia*) and spear thistle (*Cirsium vulgare*), which are all frequently abundant.

This community forms part of MU 13 Hunter Floodplain Red Gum Woodland Complex of the Hunter Remnant Vegetation Project, which Peake (2006) indicated met the DEH (2006) criteria for listing as critically endangered, and it is regionally significant.

Rough-barked Apple Woodland occurs along Big Flat Creek in the north-western part of the Study Area, as well as to the immediate north of the Study Area (**Figure 4.1**). In some locations rough-barked apple appears to have been planted, or at least to have regenerated in favourable conditions. It covers 0.3 hectare (**Table 4.5**) within the Proposed Disturbance Area, and 11 hectares in the Proposed Offset Areas. It occurs in moderate abundance in the local area. Peake (2006) considers it likely that MU 13 Hunter Floodplain Red Gum Woodland is not protected in any conservation reserves.

4.2.1.13 Forest Red Gum Riparian Woodland

Forest Red Gum Riparian Woodland occurs in riparian areas in the Proposed Disturbance Area, where it is restricted to Anvil Creek and Clark's Gully (**Table 4.5** and **Figure 4.1**). It forms a woodland to open forest (10-40% cover) that is usually mid-high (15-25 metres). Forest red gum (*Eucalyptus tereticornis*) forms the dominant canopy species, however other common trees can include rough-barked apple (*Angophora floribunda*), grey box (*Eucalyptus moluccana*) or Blakely's red gum (*Eucalyptus blakelyi*), and rarely western grey box

(*Eucalyptus microcarpa*) or yellow box (*Eucalyptus melliodora*). Black cypress pine (*Callitris endlicheri*) may also be locally abundant in some areas.

There is usually little or no understorey, however species such as native olive (*Notelaea microcarpa* var. *microcarpa*), native blackthorn (*Bursaria spinosa* subsp. *spinosa*) and hop-bush (*Dodonaea viscosa*) can be locally abundant.

The groundcover can be mid-dense to dense (30-90% cover) and is usually low (0.3-0.8 metre). Common native species include spiny-headed mat-rush (*Lomandra longifolia*), blue flax-lily (*Dianella caerulea*), weeping grass (*Microlaena stipoides* var. *stipoides*), kidney weed (*Dichondra repens*), tall sedge (*Carex appressa*), couch (*Cynodon dactylon*), common rush (*Juncus usitatus*), poison rock fern (*Cheilanthes sieberi* subsp. *sieberi*), scurvy weed (*Commelina cyanea*), knob sedge (*Carex inversa*), native geranium (*Geranium solanderi* var. *solanderi*), forest hedgehog grass (*Echinopogon ovatus*), swamp dock (*Rumex brownii*), ivy-leaved violet (*Viola hederacea*) and wood sorrel (*Oxalis exilis*). Introduced groundcovers are moderately common and include fireweed (*Senecio madagascariensis*), flatweed (*Hypochaeris radicata*), common sowthistle (*Sonchus oleraceus*), tall fleabane (*Conyza sumatrensis*), Paddy's lucerne (*Sida rhombifolia*) and spear thistle (*Cirsium vulgare*).

This community is partially equivalent to MU 13 Hunter Floodplain Red Gum Woodland Complex of the Hunter Remnant Vegetation Project, which Peake (2006) indicated met the DEH (2006) criteria for listing as critically endangered and is regionally significant.

Forest Red Gum Riparian Woodland is restricted to Anvil Creek and Clark's Gully, all within the Proposed Disturbance Area (**Figure 4.1**). It covers 51 hectares (**Table 4.5**), with the most extensive occurrence being along the southern east-west flowing part of Anvil Creek. No other occurrences are known in the local area. Peake (2006) regarded MU 13 Hunter Floodplain Red Gum Woodland Complex as being not reserved.

4.2.1.14 Tall Mixed Shrubland Complex

This community occurs only on the conglomerate outcrops of the Proposed Offset Areas (**Table 4.5** and **Figure 4.1**). It comprises a mid-high to tall (2-6 metres) shrubland that may be sparse through to dense (30-70% cover). Typically it is characterised by the presence of a number of shrub species, including heath-myrtle (*Micromyrtus sessilis*), fringed heath-myrtle (*Micromyrtus ciliata*), kunzea (*Kunzea* sp. 'Mt Kaputar'), blunt beard-heath (*Leucopogon muticus*), fringe-myrtle (*Calytrix tetragona*) and narrow-leaved geebung (*Persoonia linearis*). On occasion emergent low trees may be present, with the most common species being coast myall (*Acacia binervia*), drooping sheoak (*Allocasuarina verticillata*) and Dwyer's red gum (*Eucalyptus dwyeri*). Weeds are rare.

The groundcover is sparse (30-50% cover) and low (less than 0.3 metre in height). It is usually dominated by a small range of grasses and herbs, including *Cleistochloa rigida*, finger grass (*Digitaria ramularis*), pomax (*Pomax umbellata*), kidney weed (*Dichondra repens*) and hairy panic (*Panicum effusum*).

Vines and twiners are generally rare, but devil's twine (*Cassytha pubescens*) and false sarsaparilla (*Hardenbergia violacea*) can be common in places.

This community is partially equivalent to MU 35 Myambat Narrabeen Micromyrtus Heath of the Hunter Remnant Vegetation Project, which Peake (2006) indicated did not meet the DEH (2006) listing criteria.

Tall Mixed Shrubland Complex is restricted to the tops of conglomerate outcrops in the southern Proposed Offset Areas (**Figure 4.1**). It covers 52 hectares (**Table 4.5**), with the most extensive occurrences being around the Limb of Addy Hill and Western Rocks. It also occurs in Myambat Military Area and in Crown land to the west and north of the Study Area. Peake (2006) considers its level of reservation to be moderate to good.

4.2.1.15 Weeping Myall Woodland

This vegetation community occurs in highly restricted locations in the Study Area (**Table 4.5** and **Figure 4.1**) and is characterised solely by the presence of weeping myall (*Acacia pendula*), which typically forms a low (4-8 metres) open to closed (10-70%) structure. No other tree, low tree or shrub species occur in Weeping Myall Woodland.

The groundcover is highly diverse in this community, usually strongly reflecting the composition of the adjoining pasture. No Weeping Myall Woodland has been identified adjoining woodland or forest; all occurrences are in pasture. Groundcover species encountered at most sites include eastern cotton bush (*Maireana microphylla*), ruby saltbush (*Enchylaena tomentosa*), kangaroo grass (*Themeda australis*), wallaby grass (*Austrodanthonia fulva*), climbing saltbush (*Einadia nutans* subsp. *nutans*) and common everlasting (*Chrysocephalum apiculatum*).

At many sites weeping myall is afflicted with extensive defoliation, presumably from the procession caterpillar (*Ochrogaster contraria*). The caterpillar's large, brown shelters are very conspicuous in defoliated trees.

This community is equivalent to MU 19 Hunter Valley Weeping Myall Woodland of the Hunter Remnant Vegetation Project, which Peake (2006) indicated met the DEH (2006) listing criteria as endangered. It is listed as an endangered ecological community (EEC) under the TSC Act.

Weeping Myall Woodland occurs in three highly restricted locations, in the north-west and east of the Study Area (**Figure 4.1**), covering a total of 1 hectare (**Table 4.5**). One of the known sites is within the rail loop of the Proposed Disturbance Area, however is expected to be able to be protected within the centre of the rail loop. The other known occurrences of this community occur within the Proposed Offset Areas or outside of the Study Area along Mangoola Road. Peake (2006) indicates that this community occurs broadly between Wybong and Warkworth, occurring at only a small number of sites, none of which are in conservation areas.

4.2.1.16 Coast Myall Exposed Woodland

Coast Myall Exposed Woodland is restricted to conglomerate outcrops in the Proposed Offset Areas (**Table 4.5** and **Figure 4.1**). It is typically dominated by coast myall (*Acacia binervia*), although other low trees may be present to form the usually low (6-12 metres) woodland (10 30% cover). Other trees that may occur include grey box (*Eucalyptus moluccana*), narrow-leaved ironbark (*Eucalyptus crebra*), curracabah (*Acacia crassa* subsp. *crassa*) and black cypress pine (*Callitris endlicheri*).

Often no understorey is present, however in places a sparse (10-30%) shrub layer of 1-3 metres height occurs. Common species include blunt beard-heath (*Leucopogon muticus*), kunzea (*Kunzea* sp. 'Mt Kaputar'), narrow-leaved geebung (*Persoonia linearis*) and heath-myrtle (*Micromyrtus sessilis*). Weeds are rare.

The groundcover is sparse (30-50% cover) and low (less than 0.3 metre in height). It is usually dominated by a small range of grasses and herbs, including *Cleistochloa rigida*, finger grass (*Digitaria ramularis*), pomax (*Pomax umbellata*), kidney weed (*Dichondra repens*), hill hibiscus (*Hibiscus sturtii* var. *sturtii*), yellow burr-daisy (*Calotis lappulacea*), Australian stonecrop (*Crassula sieberiana*), berry saltbush (*Einadia hastata*), trailing speedwell (*Veronica plebeia*), bristly cloak fern (*Cheilanthes distans*), *Sida filiformis*, stout bamboo grass (*Austrostipa ramosissima*) and slender bamboo grass (*Austrostipa verticillata*).

Weeds may be moderately abundant, with the most common species including Paddy's lucerne (*Sida rhombifolia*), prickly pear (*Opuntia stricta* var. *stricta*) and tiger pear (*Opuntia aurantiaca*).

This community is equivalent to MU 33 Upper Hunter Coast Myall Exposed Forest of the Hunter Remnant Vegetation Project, which Peake (2006) indicated did not meet the DEH (2006) listing criteria.

Coast Myall Exposed Woodland is restricted to the tops of conglomerate escarpments (**Figure 4.1**), and occurs in five locations, with all but 0.2 hectare being within the Proposed Offset Areas. It covers 74 hectares (**Table 4.5**) in the Proposed Offset Areas, with the most extensive occurrences being around Wallaby Rocks, Anvil Hill and Western Rocks. It is fairly widespread in the local area, occurring in moderate abundance from northern Wollemi National Park around Martinsville east to Yengo National Park around Milbrodale. Peake (2006) regards it as moderately well reserved.

4.2.1.17 Disturbed Grassland

Disturbed Grassland is a widespread unnatural vegetation community that occurs as a result of extensive human modification of the natural woodland and open forest environments in the general locality. The structure and floristic composition of the community is highly variable, being largely dependent on previous and current land use. In general, it is an open to closed grassland of 0.1-1 metre in height, dominated by a diverse range of native and introduced grasses and forbs, with fewer sedges and ferns.

The following species include the most frequent natives that are encountered: three-awned speargrass (*Aristida vagans*), wiregrass (*Aristida ramosa*), wallaby grass (*Austrodanthonia fulva*), couch (*Cynodon dactylon*), corkscrew grass (*Austrostipa scabra*), paddock lovegrass (*Eragrostis leptostachya*), kidney weed (*Dichondra repens*), winter amulla (*Eremophila debilis*), climbing saltbush (*Einadia nutans*), eastern cottonbush (*Maireana microphylla*), hyssop loosestrife (*Lythrum hyssopifolia*), galvanised burr (*Sclerolaena birchii*), twining glycine (*Glycine clandestina*), variable glycine (*Glycine tabacina*) and star cudweed (*Euchiton involucratus*).

The following species include the most frequent introduced plants that are encountered: fireweed (*Senecio madagascariensis*), flatweed (*Hypochaeris radicata*), slender plantain (*Plantago lanceolata*), Paddy's lucerne (*Sida rhombifolia*), Pelisser's toadflax (*Linaria pelisseriana*), French flax (*Linum trigynum*) and prickly pear (*Opuntia stricta* var. *stricta*).

In many areas widely spaced trees are present; the most common species are slaty box (*Eucalyptus dawsonii*), narrow-leaved ironbark (*Eucalyptus crebra*), grey box (*Eucalyptus moluccana*) and Blakely's red gum (*Eucalyptus blakelyi*).

While the presence of this vegetation community has resulted from the clearing of forests and woodlands, it still has some conservation value for native flora and fauna. Rare or threatened plants such as tricolour donkey orchid (*Diuris tricolor*), lobed blue grass (*Bothriochloa biloba*), narrow goodenia (*Goodenia macbarronii*) and tiger orchid (*Cymbidium canaliculatum*) can still be present where suitable conditions exist. Despite this, the vegetation community is not, in itself, of conservation significance.

Disturbed Grassland is the most widespread vegetation community in the Study Area, covering 1806 hectares (**Table 4.5**), with relatively even distribution between the Proposed Disturbance Area (52%) and the Proposed Offset Areas (48%). It dominates the north-eastern and much of the eastern part of the Study Area, and is also extensive in the central-western part between Wallaby Rocks and Anvil Hill (**Figure 4.1**). This community is common and widespread in the local area and throughout the central Hunter Valley.

4.2.2 Vegetation Communities in the Vicinity but Not Within the Study Area

The vegetation communities within the area surrounding the Study Area have been mapped on **Figure 4.1** to provide context for this ecological assessment and to assist in management considerations including corridor functions. Following is a description of only those communities that have been mapped on **Figure 4.1** but are not located within the Study Area.

4.2.2.1 Spotted Gum Open Forest

Spotted Gum Open Forest is characterised by the more or less ubiquitous presence of spotted gum (*Corymbia maculata*) in the tree canopy, which ranges from 20-40% cover and 15-20 metres in height. Other canopy species may include narrow-leaved ironbark (*Eucalyptus crebra*) and grey box (*Eucalyptus moluccana*).

Low trees and shrubs may be present, the latter forming an understorey that may be open to dense and around 2-4 metres in height. Low trees may include native cherry (*Exocarpos cupressiformis*), black cypress pine (*Callitris endlicheri*) or currawang (*Acacia doratoxylon*). Shrubs may include native olive (*Notelaea microcarpa* var. *microcarpa*), gorse bitter pea (*Daviesia ulicifolia* subsp. *ulicifolia*), native holly (*Podolobium ilicifolium*), coffee bush (*Breynia oblongifolia*) or silver-stemmed wattle (*Acacia parvipinnula*).

The groundcover is usually less than 0.5 metre in height and mid-dense to dense. Common species may include threeawn wiregrass (*Aristida ramosa*), wallaby grass (*Austrodanthonia fulva*), poison rock fern (*Cheilanthes sieberi* subsp. *sieberi*), yellow burr-daisy (*Calotis lappulacea*), false sarsaparilla (*Hardenbergia violacea*) or yellow buttons (*Chrysocephalum apiculatum*), or a number of other species.

This community is partially equivalent to the spotted gum variant of MU 11 Upper Hunter White Box – Ironbark Grassy Woodland of the Hunter Remnant Vegetation Project. While Peake (2006) indicated that the community in general met the DEH (2006) listing criteria and also met the EPBC 1999 and TSC Act 1995 listed EECs, it is unlikely that this variant would meet any of the above categories.

This community occurs outside of the Study Area, north of its north-eastern boundary (**Figure 4.1**). It occurs fairly extensively in Manobalai Nature Reserve to the north-west (Peake 1999), and it is likely that it is moderately well reserved.

4.2.2.2 Ironbark – Wattle Low Exposed Woodland Complex

This grouping includes a number of vegetation communities that occur in a similar environmental setting in the local area and, for the purposes of mapping for the Anvil Hill Project, were readily treated as one group. They comprise a range of eucalypt and acacia species that form the open to mid-dense canopy (20-40%) that is usually mid-high (8-14 metres). Common canopy species include broad-leaved ironbark (*Eucalyptus fibrosa*), blue-leaved ironbark (*Eucalyptus nubila*), brown bloodwood (*Corymbia trachyphloia* subsp. *amphistomatica*), black cypress pine (*Callitris endlicheri*), currawang (*Acacia doratoxylon*), coast myall (*Acacia binervia*), narrow-leaved wattle (*Acacia linearifolia*), curracabah (*Acacia crassa* subsp. *crassa*) and, in places, spotted gum (*Corymbia maculata*).

The understorey is usually dense and mid-high, comprising a high diversity of sclerophyllous shrub species. The groundcover is usually sparse and low, but can be dense in places, especially at sheltered sites.

Collectively, it is most similar to MU 15 Western Hunter Narrabeen Exposed Grey Gum – Stringybark Woodland of the Hunter Remnant Vegetation Project, which Peake (2006) considered to be not threatened.

Ironbark – Wattle Low Exposed Woodland Complex occurs extensively on the escarpments to the north and west of the Study Area (**Figure 4.1**). It is very widespread in the local area and is well represented in the local conservation reserves.

4.2.2.3 Cypress Pine Woodland

One small area of this vegetation community is mapped just outside of the Study Area boundary in the south-western Proposed Offset Areas. The community is dominated solely by black cypress pine (*Callitris endlicheri*). It was not sampled by this study, as it occurs outside of the Study Area, however it is equivalent to MU 8 Western Hunter Narrabeen Footslopes Ironbark – Cypress Pine Woodland of Peake (2006), which includes other characteristic canopy species such as narrow leaved ironbark (*Eucalyptus crebra*), with grey gum (*Eucalyptus punctata*) and rough-barked apple (*Angophora floribunda*) being less frequent but still important.

Peake (2006) indicates that a shrubby understorey is usually, but not always, present. Numerous species can occur, but it is usually dominated by native olive (*Notelaea microcarpa* var. *microcarpa*).

Forbs and grasses are abundant, forming a sparse layer, with common species including berry saltbush (*Einadia hastata*), kidney weed (*Dichondra repens*), whiteroot (*Pratia purpurascens*), tufted bluebell (*Wahlenbergia communis*), pomax (*Pomax umbellata*), wattle mat-rush (*Lomandra filiformis*), threeawn wiregrass (*Aristida ramosa*), finger grass (*Digitaria ramularis*), weeping grass (*Microlaena stipoides* var. *stipoides*), rough saw-sedge (*Gahnia aspera*), variable saw-sedge (*Lepidosperma laterale*), poison rock fern (*Cheilanthes sieberi* subsp. *sieberi*) and variable tick-trefoil (*Desmodium varians*) (Peake 2006).

Peake (2006) regards MU 8 Western Hunter Narrabeen Footslopes Ironbark – Cypress Pine Woodland as not meeting the DEH (2006) listing criteria.

In the local area, MU 8 Western Hunter Narrabeen Footslopes Ironbark – Cypress Pine Woodland is restricted to the one occurrence immediately outside of the Study Area (**Figure 4.1**). It is fairly widespread in the Sandy Hollow – Manobalai district (Peake 2006). Peake (2006) considers its level of reservation to be moderate.

4.2.2.4 Low Shrubland

This vegetation community is mapped in one area about 700 metres to the south-west of the Study Area (**Figure 4.1**). No ground-truthing of this vegetation was undertaken, as no access was available and it was not mapped in the Study Area. Based on stereoscopic examination of the aerial photo it is likely that it is composed of a dense shrubland of about 1-3 metres in height.

4.2.2.5 Currawang Tall Woodland

This vegetation community comprises a tall (15-25 metres high) woodland (**Figure 4.1**) to the north of the Study Area. It is similar to MU 16 Upper Hunter Narrabeen Escarpment Acacia Woodland of the Hunter Remnant Vegetation Project (Peake 2006), and is dominated by a range of trees, particularly currawang (*Acacia doratoxylon*). Other common tree species include drooping sheoak (*Allocasuarina verticillata*) and Dwyer's red gum (*Eucalyptus dwyeri*), while curracabah (*Acacia crassa* subsp. *crassa*), blue-leaved ironbark (*Eucalyptus nubila*) and narrow-leaved ironbark (*Eucalyptus crebra*) are less common (Peake 2006).

A sparse to mid-dense understorey is sometimes present, although a diversity of shrub species typically occur, with narrow-leaved boronia (*Boronia anethifolia*), narrow-leaved geebung (*Persoonia linearis*) and small-leaf tea tree (*Leptospermum parvifolium*) being the most common (Peake 2006).

The groundcover is typically sparse and low, and is dominated by poison rock fern (*Cheilanthes sieberi* subsp. *sieberi*), rock fern (*Cheilanthes austrotenuifolia*), grassland wood sorrel (*Oxalis perennans*), hill raspwort (*Gonocarpus elatus*) slender violet-bush (*Hybanthus monopetalus*), *Hibbertia obtusifolia* and pomax (*Pomax umbellata*). Common grasses include *Digitaria ramularis*, *Cleistochloa rigida* and *Paspalidium criniforme* (Peake 2006). Twiners are uncommon and vines are mostly absent.

This community occurs about three kilometres to the north of the Study Area in Crown land. It also occurs more extensively in the Manobalai district (Bell 1997; Peake 1999) and Myambat Military Area (Fallding et al. 1999). Peake (2006) considers its level of reservation to be very good.

4.3 Management History of the Vegetation

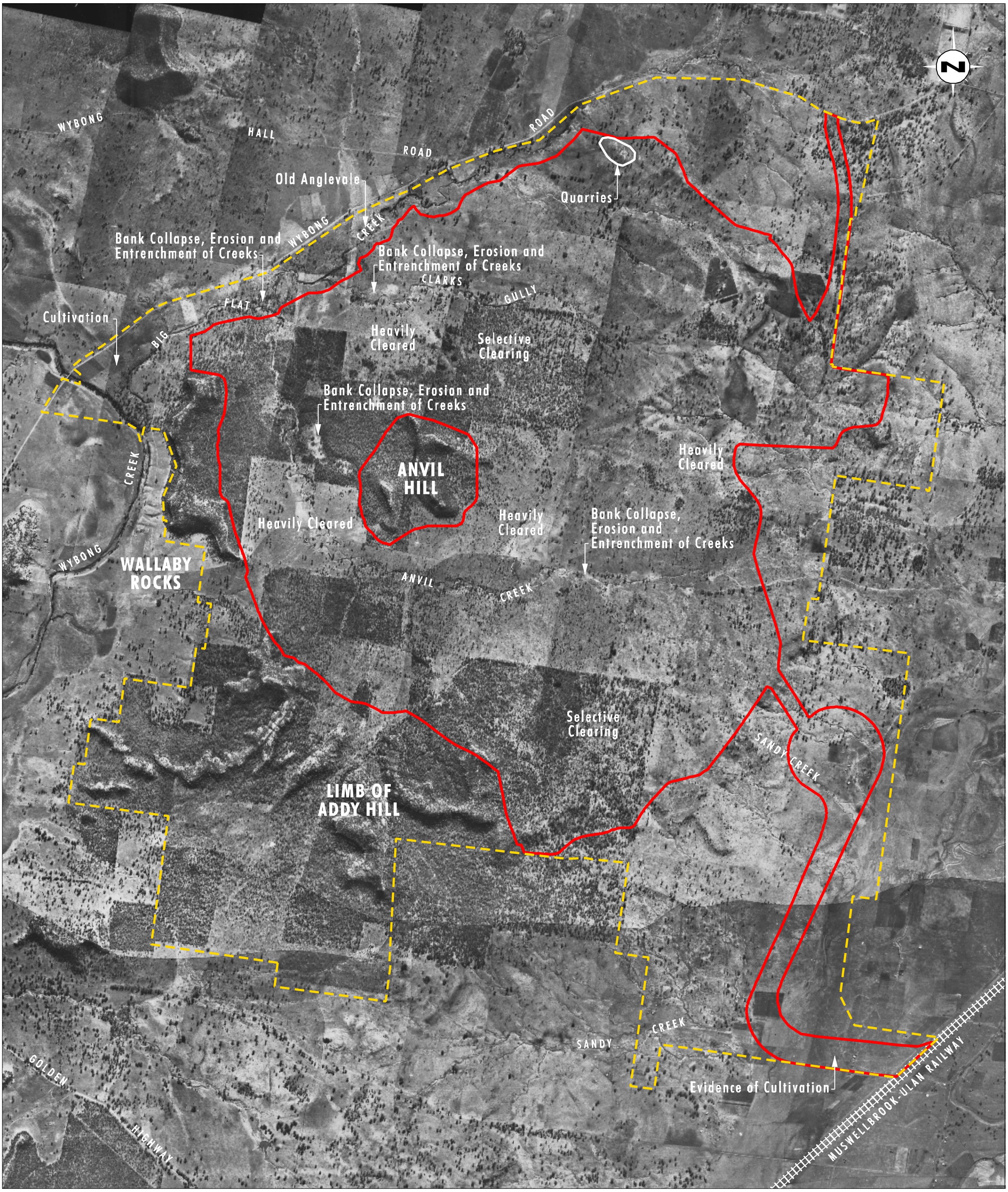
4.3.1 Historical Analysis

A review of historical aerial photographs was undertaken to ascertain the management history of the native vegetation in the Study Area. Two sets of aerial photographs were obtained from the Department of Lands: one set from the 1930s (no specific date); and one set from December 1967.

Examination of the 1930s set of photographs shows that substantial clearing in the study area had been undertaken prior to that time (**Figure 4.3**). In particular, most of the natural vegetation surrounding the southern west-flowing part of Anvil Creek had been removed, extending close to the southern foot of Anvil Hill and covering substantial areas to the east of Anvil Hill. Much of the existing Slaty Box Woodland in the north of the Proposed Disturbance Area had been cleared, while the extensive Ironbark Woodland Complex and Bulloak Woodland patches in the east of the Study Area were also absent. Extensive areas of Ironbark Woodland Complex and Slaty Box Woodland in the southern Proposed Offsets Area, to the west and north of Limb of Addy, had also been cleared. Furthermore, a large patch of woodland on the boundary between the Proposed Disturbance Area and Proposed Offset Areas between Limb of Addy and Anvil Hill was cleared. Despite this, sizeable stands of intact vegetation remained around Limb of Addy and the Western Rocks in the southern Proposed Offsets Area; to the north-east and north-west of Anvil Hill; and to the north-east of Wallaby Rocks.

Examination of the 1967 set of photographs (**Figure 4.4)** shows that much of the clearing that was evident in the 1930s photographs was then regenerating, in particular around the central part of the west-flowing Anvil Creek; to the east of Anvil Hill; on the boundary between the Proposed Disturbance Area and Proposed Offset Areas between Limb of Addy and Anvil Hill; and in the southern Proposed Offsets Area. Notwithstanding this, much of the northern Proposed Disturbance Area was still significantly cleared, as well as most of the land to the east of Anvil Hill. Substantial clearing and thinning of vegetation around the northern part of Anvil Creek (between Anvil Hill and Wallaby Rocks) and along Big Flat Creek to the west of Wallaby Rocks was also evident.

The relative areas of vegetation present in the Proposed Disturbance Area in the 1930s aerial photograph increased from 739.5 hectares (33%) to 821.3 hectares (36.7%) in the 1967 photograph, and then increased significantly to 1303.5 hectares (58.2%) in the 2003 aerial photograph (**Graph 4.1**). Likewise, the relative areas of vegetation present in the Proposed Offset Areas in the 1930s aerial photograph increased from 748.2 hectares (39.3%) to 839.3 hectares (44.1%) in the 1967 photograph, and then increased greatly to 1032.2 hectares (54.2%) in the 2004 aerial photograph (**Graph 4.1**).



Base Map: United Photos (2006), ortho-rectified by Umwelt

0 0.5 1.0 2km

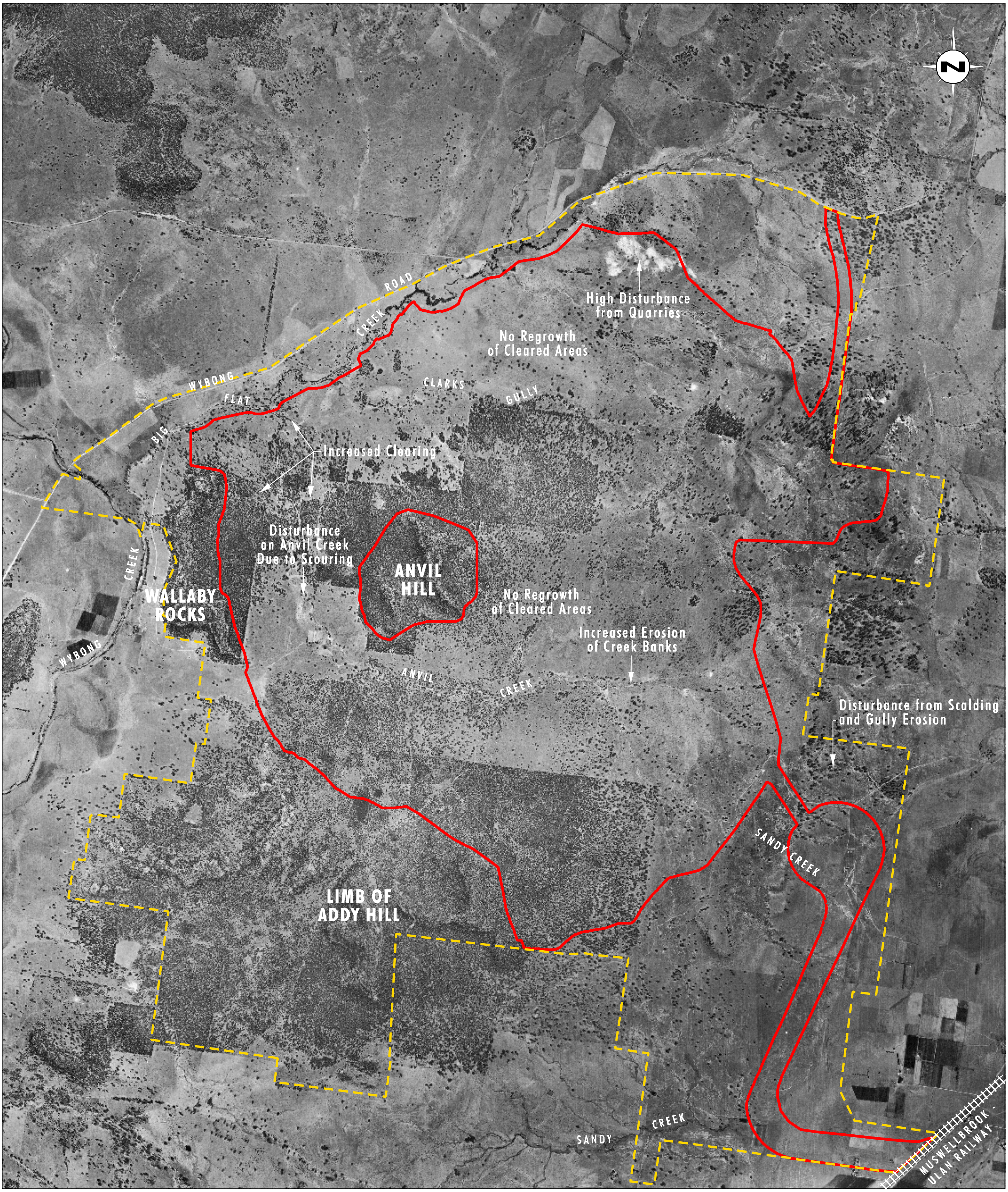
Legend

Proposed Disturbance Area

Study Area

FIGURE 4.3

1930s Aerial Photograph of Anvil Hill Study Area



Base Map: United Photos (2006), ortho-rectified by Umwelt

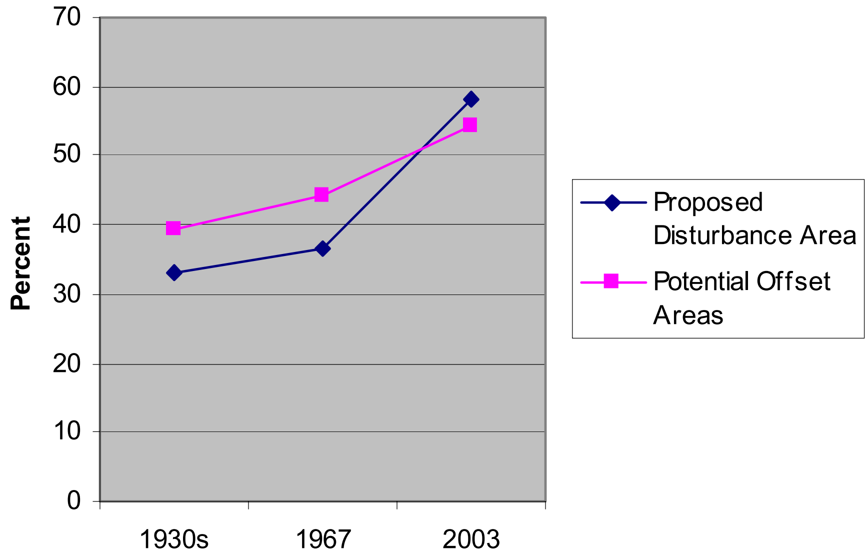
0 0.5 1.0 2km

Legend

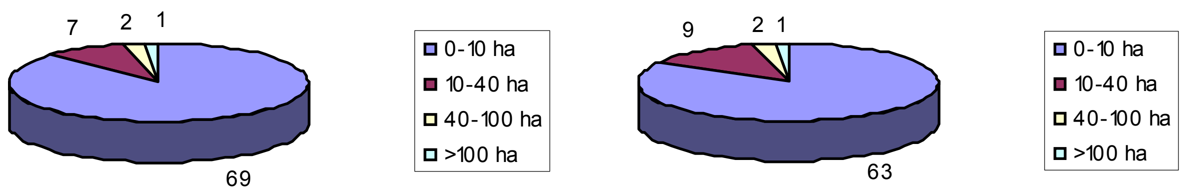
Proposed Disturbance Area
Study Area

FIGURE 4.4

1967 Aerial Photograph of Anvil Hill Study Area



Graph 4.1 - Percentage area of treed vegetation in 1930s, 1967 and 2003 aerial photographs



Graph 4.2 - Number of remnants of four size classes in the Proposed Disturbance Area (left) and the Potential Offset Areas (right), represented as proportions

GRAPHS 4.1 & 4.2

It is possible that the core of woodland vegetation present around Anvil Hill, Wallaby Rocks, Limb of Addy and the Western Rocks in the 1930s (**Figure 4.3**), and extant today (**Figure 4.1**), is "old growth" vegetation. Old growth vegetation refers to any vegetation that was present at the time of European arrival in Australia that still remains in essentially similar condition. While this vegetation could possibly be old growth, it is equally possible that it was cleared soon after European settlement of the district (c. 1830) and has since regrown. Either way it is likely that these areas comprise woodland that is at least 100 or more years old.

By contrast, the remaining extant woodland in the study area is entirely "regrowth" vegetation. Regrowth is, ecologically, any native vegetation that has been cleared and has regrown since that time.

4.3.2 Spatial Structure

As discussed in **Section 4.3.1**, both the Proposed Disturbance Area and the Proposed Offset Areas have been previously subject to extensive clearing and modification. Both areas now essentially each comprise one very large remnant, together with numerous small remnants.

To assist in understanding the degree of fragmentation in the Study Area, remnants were attributed to one of four size classes (**see Section 3.4**). In total, 79 remnants were mapped in the Proposed Disturbance Area, while 75 were mapped in the Proposed Offset Areas. **Graph 4.2** shows that the size class distribution of remnants is relatively consistent between the two areas.

When the area occupied by each of the remnant size classes is analysed, a very similar pattern is evident. Both the Proposed Disturbance Area and the Proposed Offset Areas are dominated by the single large remnant, with the smaller remnants contributing relatively little to the overall area of treed vegetation (**Graph 4.3**). In both cases the 10-40 hectare size class comprises the second-largest area of treed vegetation. "Treed vegetation" is defined as any vegetation community forming part of the Woodland, Riparian/Floodplain or Shrubland formations, and excludes Grassland.

The Proposed Disturbance Area and the Proposed Offset Areas support remnants that are very similar in size. The mean sizes of remnants for both areas are 16.5 and 13.8 hectares respectively, while the median areas are 0.5 and 0.8 hectare respectively.

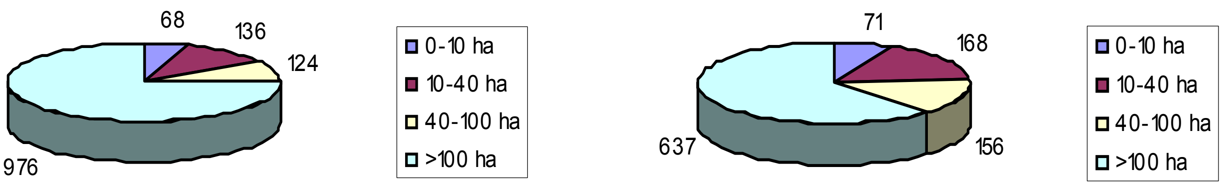
Analysis of the actual numbers of remnants, and areas covered by those remnants, in each of the size classes shows a very similar distribution between both the Proposed Disturbance Area and the Proposed Offset Areas (**Graph 4.4**). The primary difference is that the Proposed Offset Areas have an overall lower area of vegetation present.

In summary, the Proposed Disturbance Area and Proposed Offset Areas are very similar in terms of the degree of fragmentation. However, as evidenced by the 1930s aerial photograph (**Figure 4.3**), the Proposed Offset Areas support vegetation that is much older and more likely to be old growth vegetation.

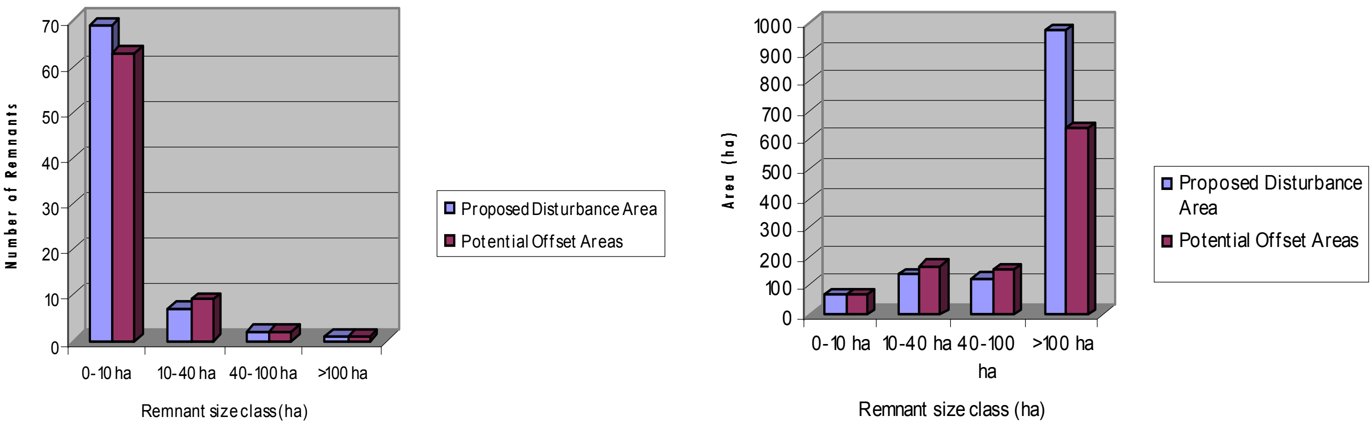
4.4 Threatened Flora Records

A detailed table of all potential threatened flora species, endangered populations and EECs is provided in **Appendix A**. Included in this list are a number of additional species that are not listed under the TSC Act 1995. These additional species include species listed under the EPBC Act 1999 and ROTAP (Rare or Threatened Australian Plant) species considered likely to have potential habitat within the Study Area.

Table 4.6 provides a list of the threatened flora species, endangered populations and EECs considered to have potential habitat within the Study Area.



Graph 4.3 - Area (in hectares) of remnants of four size classes in the Proposed Disturbance Area (left) and the Potential Offset Areas (right), represented as proportions



Graph 4.4 - Number (left) and area (right) of remnant size classes in the Proposed Disturbance Area and Potential Offset Area.

GRAPHS 4.3 & 4.4

Table 4.6 - Threatened flora species, endangered populations and endangered ecological communities with potential habitat in the Study Area

Species Name		Status		
Common Name	**Scientific name**	**ROTAP**	**TSC Act 1995**	**EPBC Act 1999**
weeping myall	*Acacia pendula* population		EP	
	Acianthus apprimus	2R		
	Boronia rubiginosa	2RCa		
lobed bluegrass	*Bothriochloa biloba*	3V		V
	Commersonia rosea	Rec. 2E	E	nominated E
tiger orchid	*Cymbidium canaliculatum* population		EP	
	Cynanchum elegans	3ECi	E	E
small snake orchid	*Diuris pedunculata*	2E	E	E
painted diuris	*Diuris tricolor*	3K	V	V
	Eucalyptus aenea	Rec. 2RC		
river red gum	*Eucalyptus camaldulensis* population		EP	
	Gonocarpus longifolius	3RC-		
narrow goodenia	*Goodenia macbarronii*	3VC-	V	V (nominated for de-listing)
Johnson's grevillea	*Grevillea johnsonii*	2RCi		
mountain grevillea	*Grevillea montana*	2KC-		
	Homoranthus cernuus	2RCa		
	Isotropis foliosa	3KC-	V (PD)	
	Kennedia retrorsa	2VCa	V	V
	Lasiopetalum longistamineum	2VC-	V	V
	Philotheca ericifolia	3RC-	V	V
	Pomaderris bodalla	Rec. 2R	V	
	Pomaderris costata	3RC-		
	Pomaderris pauciflora	3RC-		
	Pomaderris precaria	Rec. 2E		
	Pomaderris queenslandica	Rec. 3VCi	E	
	Pomaderris reperta	Rec. 2E	E	nominated E
	Prostanthera cineolifera	2K	V	V
	Prostanthera cryptandroides	2RC-t	V	V
	Prostanthera discolor	2VC-	V	V
austral toadflax	*Thesium australe*	3VCi+	V	V
	Weeping Myall Woodland EEC		EEC	

Key: E = endangered
EEC = endangered ecological community
EP = endangered population
PD = preliminary determination
Rec = recommended
V = vulnerable
*for ROTAP codes refer to Briggs and Leigh (1996)

Where sufficient information is available, these threatened species records have been mapped (**Figure 4.5**) and used in the impact assessment. Not all data sources provide sufficient information to allow records to be mapped, however threatened species records from these sources have been included within the species list provided in **Appendix E**. The following sources provide threatened species records with co-ordinate data, allowing them to be mapped:

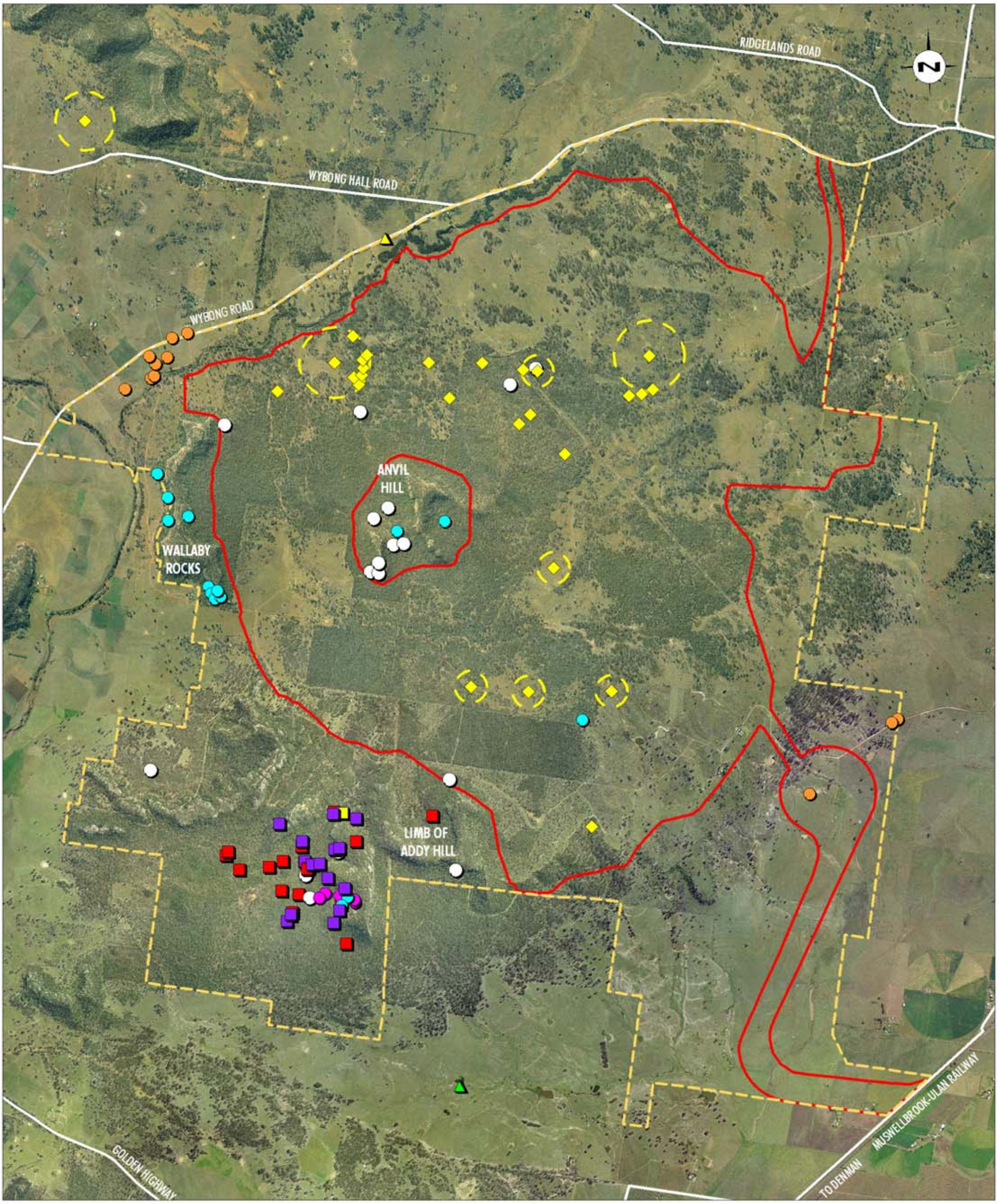
- A 20 kilometre radius search from the centre of the Study Area from the Atlas of NSW Wildlife Muswellbrook 1:100,000 Map Sheet (February 2006);
- Field survey results from HLA Envirosciences (2001 and 2002);
- Field survey results from Umwelt (2004 and 2005); and
- National Herbarium of New South Wales database search for 20 kilometre radius of the centre of the Study Area (February 2006).

The following **Table 4.7** documents the total number of records for each species, regardless of the record source.

Table 4.7 – Records of Threatened Flora in the Study Area

Common Name	Scientific Name	TSC Act 1995	EPBC Act 1999	Total Number of Records	Proposed Disturbance Area	Proposed Offset Areas
	Commersonia rosea	E	E (Nominated)	1	-	1
painted diuris	*Diuris tricolor*	V	V	1	-	1
narrow goodenia	*Goodenia macbarronii*	V	V (Nominated to de-list)	26	26	-
	Lasiopetalum longistamineum	V	V	12	-	12
	Pomaderris queenslandica	E	-	14	1	13
	Pomaderris reperta	E	E (Nominated)	16	-	16
tiger orchid	*Cymbidium canaliculatum*	Endangered Population	-	17	5	12
weeping myall	*Acacia pendula*	Endangered Population	-	8	1	7
	Weeping Myall Woodland	Endangered Ecological Community	-	2	1	1
lobed bluegrass	*Bothriochloa biloba*	-	V	1	Outside of Study Area	
mountain grevillea	*Grevillea montana*	ROTAP only		17	-	17

A total of six flora species, two endangered populations, and one endangered ecological community listed under the TSC Act 1995 have been recorded in the Study Area. In addition to this, one species listed as threatened only under the EPBC Act 1999 was recorded within the Study Area, as well as one ROTAP species.



Source: DEC Atlas of NSW Wildlife (2006), National Herbarium of NSW (2006), HLA Envirosciences (2003
Base Map: Dept. of Lands (2003), ortho-rectified by Plateau Images

0 1 2 km

Legend

Proposed Disturbance Area
Study Area

Acacia pendula
Bothriochloa biloba
Commersonia rosea
Cymbidium canaliculatum
Diuris tricolor
Goodenia macbarronii (areas)
Goodenia macbarronii sites
Grevillea montana
Pomaderris queenslandica
Lasiopetalum longistamineum
Pomaderris reperta

FIGURE 4.5
Threatened and Significant Flora Locations

Detailed Tests of Ecological Significance for each recorded threatened species are provided within **Appendix F** for those species listed under the TSC Act 1995, and in **Appendix G** for those species listed under the EPBC Act 1999. Included in these assessments, are those species that are considered to have potential habitat within the Study Area, however were not recorded during surveys.

4.4.1 Recorded Threatened Species, Endangered Populations and Endangered Ecological Communities

The following threatened species, endangered populations and EECs (as listed under the TSC Act 1995 and EPBC Act 1999) were recorded within the Study Area either as part of the current survey, or from other sources such as previous surveys, database searches or literature reviews.

Details of the number and locations of these records, as well as any relevant ecological information relating to these records are provided below, as well as an assessment of the amount of known habitat (defined as vegetation communities in which each species was recorded) that will require removal as part of the Project. It is important to note that this assessment includes only communities from which the species was recorded. One recognised limitation of this assessment is that there is the potential for the species to occur within other communities of the Study Area. However, this assessment is based on records that came from field surveys conducted by Umwelt (2004 and 2005) and HLA Envirosciences (2001 and 2002).

4.4.1.1 *Commersonia rosea*

Commersonia rosea is a prostrate shrub 0.1-0.3 metre high, producing trailing branches up to 60 cm long (Bell & Copeland 2004). Flowering has been observed in August, November, January and February (Bell & Copeland 2004). Prior to this study, it was only known from four localities in the Sandy Hollow district of the upper Hunter Valley, New South Wales, all locations being within an 8 kilometre radius of Sandy Hollow (DEC 2006c). This species has been recorded from skeletal sandy soils derived from Triassic Narrabeen sandstone, in scrub or heath vegetation, and is believed to be fire-ephemeral, flowering and fruiting only after disturbance has occurred (Bell & Copeland 2004). *Commersonia rosea* occupies relatively small areas at its known sites and has a total population of less than 200 plants (DEC 2006c). None of the known populations of this species are within conservation reserves (DEC 2006c).

Commersonia rosea was recorded on one occasion during the survey period, being located on the edge of the Tall Mixed Shrubland Complex within the Proposed Offset Areas. Vegetation community mapping within the Study Area has identified a total of 51.6 hectares of this vegetation community within the Study Area, all of which lies within the Proposed Offset Areas. There is the potential that this species could occur within other vegetation communities and formations within the Study Area. On the basis of vegetation formations, this species was recorded from the Shrubland formation within the Proposed Offset Areas. The Study Area contains a total of 126.9 hectares of this formation, all but 0.1 hectare of which occurs within the Proposed Offset Areas.

4.4.1.2 Painted diuris - *diuris tricolor*

Painted diuris is a terrestrial herb flowering from September to November (Jones 1993b). Diuris tricolor grows in sclerophyll forest among grass and is often found with *Callitris* (Jones 1993b). *Diuris tricolor* has been recorded on the Northern and Central Tablelands and Slopes (Jones 1993b). It is found in sandy soils, either on flats or small rises. This species is sporadically distributed on the western slopes of NSW, extending from south of Narrandera to the far north of NSW. Localities include the Condobolin-Nymagee road, Wattamondara towards Cowra, Cooyal, Adelong, Red Hill north of Narrandera, Coolamon, near Darlington Point, Eugowra, Girilambone, Dubbo, Muswellbrook, and several sites west of Wagga

Wagga (DEC 2006bt). The Muswellbrook local government area is the eastern limit of the species range and the only recorded occurrence of *D. tricolor* in the Sydney Basin Bioregion (Australia's Virtual Herbarium 2006). The *D. tricolor* population in Muswellbrook appears to be an isolated population and therefore this population may be genetically distinct. The species is considered likely to have declined in recent years and is threatened by the spread of invasive, exotic grasses, such as Coolatai grass (*Hyparrhenia hirta*) (Peake 2006).

Painted diuris was recorded on one occasion during the survey period, being located within Disturbed Grassland in the Proposed Offset Areas boundary. Vegetation community mapping within the Study Area has identified a total of 1806 hectares of this vegetation community within the Study Area. Of this, 934 hectares fall within the Proposed Disturbance Area, with the remaining 872 hectares falling within the Proposed Offset Areas. There is the potential that this species could occur within other vegetation communities and formations within the Study Area. On the basis of vegetation formations, this species was recorded from the Grassland formation, which covers the same area as the Disturbed Grassland vegetation community.

4.4.1.3 Narrow goodenia - *Goodenia macbarronii*

Narrow goodenia is a small, annual herb to 30 cm high with peak flowering time occurring October to March (Carolin 1992). Narrow goodenia grows in damp sandy soils in seepages. The species is usually found in shaded, seasonally damp sites in clay-loam, sandy-loam and sandy soils. Habitats in NSW include a recently graded roadside drain adjacent to narrow-leaved ironbark (*Eucalyptus crebra*) and white cypress pine (*Callitris glaucophylla*) woodland, dry eucalypt forest with low shrubby undergrowth in sandy soil, damp sandy patches in bushland areas, along roadsides, near water in a shallow excavation which has exposed the clay subsoil, on the banks of a sandy creek and in Blakely's red gum (*Eucalyptus blakelyi*) and rough-barked apple (*Angophora floribunda*) woodland (DEC 2006d). Sites often have some form of recent disturbance, such as depressions made by grading and excavation along roadsides. Other sites include grazed paddocks and clearings with a large proportion of weed and exotic species, and cleared open grazing land which was formerly eucalypt woodland (DEC 2006d). This species grows on the western slopes of the Great Dividing Range in NSW, south from the Guyra and Inverell districts. It is widely distributed throughout the tablelands, western slopes and western plains, and also occurs in north-eastern Victoria and the Darling Downs in Queensland (DEC 2006d). In NSW it has been recorded at Tingha, Guyra, the Warrumbungle Ranges, east of Rylstone, the Pilliga and Denobollie State Forests, the Narrabri, Coonabarabran, Torrington and Tocumwal districts, Grenfell, Weddin Mountain, Gungal, the Milthorpe district, and Holbrook (the type locality) (DEC 2006d). In the Hunter Valley, the species is only known to occur in the Wybong district where several sub-populations have been recorded (Peake 2006).

Narrow goodenia was recorded from 12 different locations within the Study Area. Each consisted of a distinct sub-population, and these often span a number of vegetation communities. Those vegetation communities which contain records of this species include: Slaty Box Woodland, Ironbark Woodland Complex, Grassland, Bulloak Woodland, Forest Red Gum Riparian Woodland, Swamp Oak Riparian Forest and Paperbark Woodland. All of the known records of this species were from the Proposed Disturbance Area. When combining the total area of mapped vegetation communities containing records for this species, there is a total of 3921 hectares of known habitat types for this species within the Study Area. Of this, 2237 hectares fall within the Proposed Disturbance Area, with the remaining 1685 hectares falling within the Proposed Offset Areas. There is the potential that this species could occur within other vegetation communities and formations within the Study Area. On the basis of vegetation formations, this species was recorded from the Woodland, Grassland, Riparian/Floodplain formations within the Proposed Disturbance Area. The Study Area contains a total of 4015 hectares of these formations. Of this, 2238 hectares are located within the Proposed Disturbance Area, with the remaining 1777 hectares being located within the Proposed Offset Areas.

4.4.1.4 *Lasiopetalum longistamineum*

Lasiopetalum longistamineum is a spreading shrub to 1.5 metres high, flowering in spring (Harden 2000). The species typically grows in rich alluvial deposits and is only known to occur within the Central West Slopes botanical subdivision (Harden 2000). It has been recorded from the Mt Dangar - Gungal area within Merriwa and Muswellbrook Local Government Areas. A couple of sites are recorded within Goulburn River National Park (DEC 2006e).

Lasiopetalum longistamineum was recorded on five occasions during the survey period, being located within the Ironbark Woodland Complex, Sheltered Grey Gum Woodland and Tall Mixed Shrubland Complex within the Proposed Offset Areas. Vegetation community mapping within the Study Area has identified a total of 1523 hectares of these vegetation communities within the Study Area. Of this, 886 hectares fall within the Proposed Disturbance Area, with the remaining 637 hectares falling within the Proposed Offset Areas. There is the potential that this species could occur within other vegetation communities and formations within the Study Area. On the basis of vegetation formations, this species was recorded from the Woodland and Shrubland formations within the Proposed Offset Areas. The Study Area contains a total of 2252 hectares of these formations. Of this, 1251 hectares are located within the Proposed Disturbance Area, with the remaining 1001 hectares being located within the Proposed Offset Areas.

4.4.1.5 *Pomaderris queenslandica*

This species is a medium-sized shrub 2-3 metres high, flowering during spring and summer (DEC 2006f). It has a widely scattered distribution, but is not common in north-east NSW and in Queensland (DEC 2006f). It is only known from a few locations on the New England Tablelands and North West Slopes, including near Torrington and Coolatai, and also from several locations on the NSW north coast (DEC 2006f). Within NSW, it occurs on the slopes north from the Peak Hill district and also in the Gloucester district (Harden 2000a). In the Hunter Valley, the species has been recorded at Myambat Military Area (Fallding et al. 1999), on the slopes of the Glen Range in Towarri NP (Hill et al. 2001) and also in Manobalai NR (Bell 1997). The species typically occurs in open forest (Harden 2000), especially in sheltered locations (Fallding et al. 1999). It is also found in moist eucalypt forest or sheltered woodlands with a shrubby understorey, and occasionally along creeks (DEC 2006f).

Pomaderris queenslandica was recorded on 13 occasions during the survey period, being located within the following vegetation communities: Ironbark Woodland Complex in the Proposed Disturbance Area, and Sheltered Grey Gum Woodland, Ironbark Woodland Complex and Coast Myall Exposed Woodland within the Proposed Offset Areas. When combining the total area of vegetation communities containing records of this species, there is 1546 hectares of potential habitat within the Study Area. Of this, 886 hectares fall within the Proposed Disturbance Area, with the remaining 660 hectares falling within the Proposed Offset Areas. There is the potential that this species could occur within other vegetation communities and formations within the Study Area. On the basis of vegetation formations, this species was recorded from the Woodland formation within the Proposed Disturbance Area and the Woodland and Shrubland formations within the Proposed Offset Areas. The Study Area contains a total of 2252 hectares of these formations. Of this, 1251 hectares are located within the Proposed Disturbance Area, with the remaining 1001 hectares being located within the Proposed Offset Areas.

4.4.1.6 *Pomaderris reperta*

A shrub growing 1-3 metres high with densely villous young stems (Walsh & Coates 1997). One record has shown that *P. reperta* flowers in October (Walsh & Coates 1997), but in the Study Area it was observed flowering in November. This species has been recorded from a small number of sites along a single ridgeline near Denman in the upper Hunter Valley (DEC 2006g). It has been recorded from the Myambat Military Area (Fallding et al. 1999) and also west of Denman (Bell 2001). It typically occurs in dry sclerophyll woodland (Harden 2000) on rocky slopes and sandy soils (Fallding et al. 1999) derived from Hawkesbury Sandstones (Walsh & Coates 1997). This species is primarily associated with the canopy species narrow-leaved ironbark (*Eucalyptus crebra*), Blakely's red gum (*Eucalyptus blakelyi*) (Walsh & Coates 1997), and grey box (*Eucalyptus molucanna*) (Fallding et al. 1999). *Pomaderris reperta* has not previously been recorded within any formal conservation reserves, however approximately 20-40 plants have been recorded within the Myambat Military Area which is managed by the Commonwealth Department of Defence (Fallding et al. 1999).

Pomaderris reperta was recorded on 16 occasions during the survey period, being located within the Ironbark Woodland Complex, Tall Mixed Shrubland Complex and Sheltered Grey Gum Woodland within the Proposed Offset Areas. Vegetation community mapping within the Study Area has identified a total of 1523 hectares of these vegetation. Of this, 886 hectares fall within the Proposed Disturbance Area, with the remaining 637 hectares falling within the Proposed Offset Areas. There is the potential that this species could occur within other vegetation communities and formations within the Study Area. On the basis of vegetation formations, this species was recorded from the Woodland and Shrubland formations within the Proposed Offset Areas. The Study Area contains a total of 2252 hectares of these formations. Of this, 1251 hectares are located within the Proposed Disturbance Area, with the remaining 1001 hectares being located within the Proposed Offset Areas.

4.4.1.7 *Cymbidium canaliculatum* – Endangered Population

Tiger orchid (*Cymbidium canaliculatum*)is an epiphyte with sympodial growth flowering during September to October (Jones 1993a) or November (Weston 1993). The species grows in tree hollows in dry sclerophyll forest or woodland (Weston 1993). Within the Hunter Valley, the species is most commonly found in white box-dominated woodlands at a height of 2-6 metres above ground level (Peake et al. in prep. c). Tiger orchid typically grows on white box (*Eucalyptus albens*), however it has been observed growing on other species such as slaty box (*E. dawsonii*), narrow-leaved ironbark (*E. crebra*), grey box (*E. moluccana*), rough-barked apple (*Angophora floribunda*) and cooba (*Acacia salicina*) (Peake et al. in prep. c). The species is chiefly found in inland districts north from the Hunter Valley and west to New Angledool (Weston 1993). It occurs widely in Queensland, the Northern Territory and in the northern parts of Western Australia (Jones 1993a). Regionally, *C. canaliculatum* occurs throughout the Hunter Valley west of Jerrys Plains and Gresford, with an estimated 200 to 500 individuals (Peake et al. in prep. a). This species is not believed to be well represented in conservation areas with an estimated 90% of individuals in the Hunter Valley occurring on private land (Peake et al. in prep. a).

Tiger orchid was recorded on 17 occasions during the survey period, being located within the Ironbark Woodland Complex, Bulloak Woodland and Slaty Box Woodland within the Proposed Disturbance Area, and Ironbark Woodland Complex, Sheltered Grey Gum Woodland and Slaty Box Woodland within the Proposed Offset Areas. Vegetation community mapping within the Study Area has identified a total of 2099 hectares of these vegetation communities within the Study Area. Of this, 1231 hectares fall within the Proposed Disturbance Area, with the remaining 868 hectares falling within the Proposed Offset Areas. There is the potential that this species could occur within other vegetation communities and formations within the Study Area. On the basis of vegetation formations, this species was recorded from the Woodland within the Proposed Disturbance Area and the Woodland formation within the Proposed Offset Areas. The Study Area contains a total of 2125 hectares of these formations. Of this, 1251 hectares are located within the Proposed Disturbance Area, with the remaining 874 hectares being located within the Proposed Offset Areas.

4.4.1.8 *Acacia pendula* – Endangered Population

The endangered population of weeping myall (*Acacia pendula*) consists of a disjunct population of fewer than 1000 individuals that occurs in the Hunter Valley at the eastern distributional limit of the species' range (DEC 2006h). The trees are erect or spreading 5-13 metres high with a pendulous habit. Their bark is hard, fissured, dark grey to black (DEC 2006h). The species occurs on the western slopes, western plains and far western plains of NSW, and south into Victoria and north into Queensland. This Hunter population is known to occur naturally as far east as Warkworth, and extends north-west to Muswellbrook and to the west of Muswellbrook at Wybong (DEC 2006h). Examples of this population have only recorded to date about 15 locations, including Jerrys Plains, Edderton, Wybong, Appletree Creek, Warkworth and Appletree Flat. Within the Hunter catchment the species typically occurs on heavy soils, sometimes on the margins of small floodplains, but also in more undulating locations. It is not known to occur within any conservation areas (DEC 2006h).

Weeping myall was recorded on nine occasions during the survey period, being located within the Disturbed Grassland and Weeping Myall Woodland vegetation communities within the Proposed Disturbance Area and Proposed Offset Areas. These records came from one area within the Proposed Disturbance Area and one area within the Proposed Offset Areas, with these clusters of records representing two examples of both the Weeping Myall (*Acacia pendula*) endangered population, and the Hunter Valley Weeping Myall Woodland endangered ecological community. The very small occurrence of this population within the Proposed Disturbance Area is located within the rail loop, and is expected to be able to be protected in the centre of the rail loop. Vegetation community mapping within the Study Area has identified a total of 1807 hectares of these vegetation communities within the Study Area. Of this, 934 hectares fall within the Proposed Disturbance Area, with the remaining 873 hectares falling within the Proposed Offset Areas. There is the potential that this species could occur within other vegetation communities and formations within the Study Area. On the basis of vegetation formations, this species was recorded from the Woodland formation of the Proposed Disturbance Area and Grassland and Woodland formations within the Proposed Offset Areas. The Study Area contains a total of 3931 hectares of these formations. Of this, 2185 hectares are located within the Proposed Disturbance Area, with the remaining 1746 hectares being located within the Proposed Offset Areas.

4.4.1.9 Weeping Myall Woodland – Endangered Ecological Community

The Hunter Valley Weeping Myall Woodland has a dense to open tree canopy to about 15 meters tall with the most common species being weeping myall (*Acacia pendula*). Other canopy species present may include narrow-leaved ironbark (*Eucalyptus crebra*), cooba (*Acacia salicina*) and trees within the *A. homolophylla – A. melvillei* complex (NSW Scientific Committee 2005a). Shrub species may include stiff canthium (*Canthium buxifolium*), sticky hopbush (*Dodonaea viscosa*), wilga (*Geijera parviflora*), native olive (*Notelaea microcarpa* subsp. *microcarpa*) and silver cassia (*Senna zygophylla*) (NSW Scientific Committee 2005). The groundcover varies from dense to sparse and comprises native grasses and herbs. This community is currently known from parts of the Muswellbrook and Singleton local government areas, but may also occur elsewhere in the Sydney Basin Bioregion (NSW Scientific Committee 2005). The total remaining area of this community is estimated to be less than ten hectares (Peake 2006) and the community is not known to occur within any conservation reserves (NSW Scientific Committee 2005a).

Weeping Myall Woodland was recorded on two occasions during the survey period, with one example of this endangered ecological community being located within the Proposed Disturbance Area and Proposed Offset Areas. Vegetation community mapping within the Study Area has identified a total of one hectare of this vegetation community within the Study Area. While a small amount of this vegetation community occurs within the Proposed Disturbance Area, it is located in the centre of the rail loop and is expected to be able to be conserved.

4.4.1.10 Lobed bluegrass - *Bothriochloa biloba*

Lobed bluegrass is an erect or decumbent caespitose perennial to c. 1 metre high, flowering during summer (Jacobs and Wall 1993). The species typically grows in woodlands on poorer soils (Wheeler et al. 2002), and is known to occur on slopes and northern parts of NSW, and Queensland (Peake 2006). Regionally, the species has been recorded across much of the central and upper Hunter Valley with fewer records in the lower Hunter but as far east as Maitland (Hill 2003). Bean (1999) suggested that grazing may have a positive effect on this species in two ways: firstly, unrestricted grazing reduces the growth the dominant purple wiregrass (*Aristida ramosa*); and secondly, stock selectively graze grass species other than lobed bluegrass because of its coarser culms. Abnormal embryology has been suggested as the reason for poor seed production by this species (Yu et al. 2003).

Lobed bluegrass was recorded on one occasion during the survey period, being located within the Disturbed Grassland to the south outside of the Proposed Offset Areas boundary. Vegetation community mapping within the Study Area has identified a total of 1806 hectares of this vegetation community within the Study Area. Of this, 934 hectares fall within the Proposed Disturbance Area, with the remaining 872 hectares falling within the Proposed Offset Areas. There is the potential that this species could occur within other vegetation communities and formations within the Study Area. On the basis of vegetation formations, this species was recorded from the Grassland formation adjacent to (although outside of) the Proposed Offset Areas. The Study Area contains a total of 1806 hectares of this formation. Of this, 934 hectares are located within the Proposed Disturbance Area, with the remaining 872 hectares being located within the Proposed Offset Areas.

4.4.1.11 Mountain grevillea - *Grevillea montana*

Mountain grevillea is a spreading shrub 0.5-1.5 metres high flowering mainly from September and October (Makinson 2002). The species typically grows in open forest in sandy soils over mixed sedimentary substrates and is found in the southern part of the Hunter Valley from Denman to Kurri Kurri (Makinson 2002).

Mountain grevillea was recorded on 17 occasions during the survey period, being located within the Ironbark Woodland Complex, Sheltered Grey Gum Woodland, Tall Mixed Shrubland Complex and Drooping Sheoak Woodland within the Proposed Offset Areas. Vegetation community mapping within the Study Area has identified a total of 1526 hectares of these vegetation communities within the Study Area. Of this, 887 hectares fall within the Proposed Disturbance Area, with the remaining 638 hectares falling within the Proposed Offset Areas. There is the potential that this species could occur within other vegetation communities and formations within the Study Area. On the basis of vegetation formations, this species was recorded from the Woodland and Shrubland formations within the Proposed Offset Areas. The Study Area contains a total of 2252 hectares of these formations. Of this, 1251 hectares are located within the Proposed Disturbance Area, with the remaining 1001 hectares being located within the Proposed Offset Areas.

4.5 Threatened Flora Species with no Potential Habitat

Appendix A provides a list of threatened flora species that are known, or have the potential to occur in the vicinity of the Study Area. These species were identified from a number of sources, including literature reviews, database searches for a 20 kilometre radius from the Study Area and professional opinion. Many of these species are considered unlikely to occur in the Study Area, as potential habitat for these species is generally limited. Each of these species is identified below, and a justification is provided for their exclusion from further consideration in this assessment.

***Acacia bulgaensis* –** this species is confined to the Bulga – Milbrodale - Broke area. It grows in sclerophyll woodland or forest on sandstone or shale (DEC 2006i).

There are no records of this species on the Muswellbrook 1:100,000 Map Sheet, and it is unlikely that the area covered by this sheet is an important area for this species. Despite extensive seasonal surveys, this species was not recorded within the Study Area, and it is considered unlikely that potential habitat exists for this species within the Study Area, or in the immediate locality.

***Acacia dangarensis* –** this species is confined to the summit and surrounding slopes of Mount Dangar south of Merriwa, within Goulburn River National Park. It occurs in pure stands or as a co-dominant tree in sclerophyll woodland on the edge of dry rainforest on basalt and basalt colluvium (DEC 2006j).

There are no records of this species on the Muswellbrook 1:100,000 Map Sheet, and it is unlikely that the area covered by this sheet is an important area for this species. Despite extensive seasonal surveys, this species was not recorded within the Study Area, and it is considered unlikely that potential habitat exists for this species within the Study Area, or in the immediate locality.

***Acacia flocktoniae* –** this species is found only in the southern Blue Mountains (at Mount Victoria, Megalong Valley and Yerranderie). It was previously recorded from the Manobalai Vacant Crown Land (Bell 1997). This species grows in dry sclerophyll forest on sandstone (DEC 2006k).

There are no records of this species on the Muswellbrook 1:100,000 Map Sheet, and it is unlikely that the area covered by this sheet is an important area for this species. Despite extensive seasonal surveys, this species was not recorded within the Study Area, and it is considered unlikely that potential habitat exists for this species within the Study Area, or in the immediate locality.

***Callistemon linearifolius* –** this species has been recorded from the Georges River to Hawkesbury River in the Sydney area, and north to the Nelson Bay area of NSW. For the Sydney area, recent records are limited to the Hornsby Plateau area near the Hawkesbury River (DEC 2006l). Habitat is generally recorded as dry sclerophyll forest on the coast and adjacent ranges.

There are no records of this species on the Muswellbrook 1:100,000 Map Sheet, and it is unlikely that the area covered by this sheet is an important area for this species. Despite extensive seasonal surveys, this species was not recorded within the Study Area, and it is considered unlikely that potential habitat exists for this species within the Study Area, or in the immediate locality.

***Digitaria porrecta* - finger panic grass –** this species occurs in NSW and Queensland. In NSW it is found on the north-west slopes and plains, from near Moree South to Tambar Springs and from Tamworth to Coonabarabran. This species grows in native grassland, woodland or open forest with a grassy understorey on richer soils. It's often found along roadsides and travelling stock routes where there is light grazing and occasional fire.

There are no records of this species on the Muswellbrook 1:100,000 Map Sheet, and it is unlikely that the area covered by this sheet is an important area for this species. Despite extensive seasonal surveys, this species was not recorded within the Study Area, and it is considered unlikely that potential habitat exists for this species within the Study Area, or in the immediate locality.

***Eucalyptus glaucina* –** this species is found only on the north coast of NSW in two major disjunct districts: near Casino, where it can be locally common; and farther south, from Taree to Broke, west of Maitland. This species grows in grassy woodland and dry eucalypt forest on deep moderately fertile and well-watered soils (DEC 2006m).

There are no records of this species on the Muswellbrook 1:100,000 Map Sheet, and it is unlikely that the area covered by this sheet is an important area for this species. Despite extensive seasonal surveys, this species was not recorded within the Study Area, and it is considered unlikely that potential habitat exists for this species within the Study Area, or in the immediate locality.

Eucalyptus pumila **- Pokolbin mallee –** this species is currently known only from a single population west of Pokolbin in the Hunter Valley. Historical records also exist for Wyong and Sandy Hollow, however, it has not been recorded recently in those areas. It is likely that the Sandy Hollow record was actually confused with *Eucalyptus aenea* (Peake 2006). The single known population occupies north-west facing slopes derived from sandstone. Present as a mid-canopy species to a height of six metres within dry sclerophyll woodland which has a canopy comprising *Eucalyptus fibrosa, Callistris endicheri* and, to a lesser extent, *Corymbia maculata* (DEC 2006n).

With only one questionable record of this species on the Muswellbrook 1:100,000 Map Sheet, it is unlikely that the area covered by this sheet is an important area for this species. The record is from Sandy Hollow, to the west of the Study Area.

Despite extensive seasonal surveys, this species was not recorded within the Study Area, and it is considered unlikely that potential habitat exists for this species within the Study Area, or in the immediate locality.

Grevillea parviflora **subsp. *parviflora* –** this species has a widespread but sporadic distribution within the Sydney Basin Bioregion. The main occurrence is centred south of Sydney in the Appin-Wedderburn-Picton-Bargo districts associated with the Nepean and Georges Rivers. Disjunct northern populations are found in the Lower Hunter Valley at Kurri Kurri and Heddon Greta and on the western shores of Lake Macquarie at Dooralong, Cooranbong and Awaba. It occurs on sandy clay loam soils, on crests, upper slopes or flat plains in both low-lying areas between 30-65 metres ASL (particularly Lower Hunter Valley and Lake Macquarie) and on higher topography between 200-300 metres ASL south of Sydney.

There are no records of this species on the Muswellbrook 1:100,000 Map Sheet, and it is unlikely that the area covered by this sheet is an important area for this species. Despite extensive seasonal surveys, this species was not recorded within the Study Area, and it is considered unlikely that potential habitat exists for this species within the Study Area, or in the immediate locality.

Homoranthus darwinioides **–** this species occurs in the central tablelands and western slopes of NSW, occurring from Putty to the Dubbo district. It is found west of Muswellbrook between Merriwa and Bylong, and north of Merriwa to Goonoo State Forest. The species has been collected from Lee's Pinch in Goulburn River National Park, but not relocated at its original locality north of Mount Coricudgy above the headwaters of Widden Brook (DEC 2006o). It grows in dry sclerophyll forest or woodland, usually on sandstone outcrops or ridges. It has been recorded on sloping ridges in *Eucalyptus* and *Callitris* woodland on thin sandy soil and in heath macchia with *Eucalyptus* and *Acacia*. It is usually found in gravely sandy soils in various woodland habitats with shrubby understoreys. Landforms include sloping ridges, gentle south facing slopes, and a slight depression on a roadside with loamy sand (DEC 2006o).

There are no records of this species on the Muswellbrook 1:100,000 Map Sheet, and it is unlikely that the area covered by this sheet is an important area for this species. Despite extensive seasonal surveys, this species was not recorded within the Study Area, and it is considered unlikely that potential habitat exists for this species within the Study Area, or in the immediate locality.

Olearia cordata **–** This species is recorded as being restricted to the south-western Hunter Plateau, eastern Colo Plateau, with southern outliers recorded in the far north-west of the Hornsby Plateau near Wisemans Ferry east of Maroota, and one record near Sackville adjoining the Hawkesbury- Nepean River (DEC 2006p).

Recorded habitat for this species is generally woodland on exposed Hawkesbury Sandstone ridges. Soils are shallow or skeletal and are usually neutral to slightly acidic. Records are 150–500 metres ASL on steep to gentle slopes (Maryott-Brown and Wilks 1993). The species tends to prefer the more sheltered easterly aspects.

There are no records of this species on the Muswellbrook 1:100,000 Map Sheet, and it is unlikely that the area covered by this sheet is an important area for this species. Despite extensive seasonal surveys, this species was not recorded within the Study Area, and it is considered unlikely that potential habitat exists for this species within the Study Area, or in the immediate locality.

***Ozothamnus tessellatus* –** this species is restricted to a few locations north of Rylstone. It grows in eucalypt woodland (DEC 2006q).

With only one record of this species on the Muswellbrook 1:100,000 Map Sheet, it is unlikely that the area covered by this sheet is an important area for this species. This record is located near to Cox's Gap, to the north of the Study Area. Despite extensive seasonal surveys, this species was not recorded within the Study Area, and it is considered unlikely that potential habitat exists for this species within the Study Area, or in the immediate locality.

***Persoonia marginata* –** this species is known from only four disjunct locations on the Central Tablelands and Central Coast (DEC 2006r). The core of the species distribution is within Clandulla State Forest, west of Kandos. Disjunct populations occur to the north at Dingo Creek and Mount Dangar within the Wollemi and Goulburn River National Parks; to the south within Ben Bullen State Forest, south-east of Capertee; and to the south-east at Devils Hole, north of Colo Heights within Parr State Recreation Area. It grows in dry sclerophyll forest and woodland communities on sandstone (DEC 2006r).

There are no records of this species on the Muswellbrook 1:100,000 Map Sheet, and it is unlikely that the area covered by this sheet is an important area for this species. Despite extensive seasonal surveys, this species was not recorded within the Study Area, and it is considered unlikely that potential habitat exists for this species within the Study Area, or in the immediate locality.

***Phebalium squamulosum* subsp. *verrucosum* –** this species is found from Wollomombi Gorge to Tia Falls. It grows in woodland and dry rainforest on ridges (DEC 2006s).

There are no records of this species on the Muswellbrook 1:100,000 Map Sheet, and it is unlikely that the area covered by this sheet is an important area for this species. Despite extensive seasonal surveys, this species was not recorded within the Study Area, and it is considered unlikely that potential habitat exists for this species within the Study Area, or in the immediate locality.

***Picris evae* –** this species occurs north from the Inverell area and grows in black soils (DEC 2006t).

There are no records of this species on the Muswellbrook 1:100,000 Map Sheet, and it is unlikely that the area covered by this sheet is an important area for this species. Despite extensive seasonal surveys, this species was not recorded within the Study Area, and it is considered unlikely that potential habitat exists for this species within the Study Area, or in the immediate locality.

***Pomaderris brunnea* - rufous pomaderris –** this species is found in a very limited area around the Nepean and Hawkesbury Rivers, including the Bargo area. It also occurs at Walcha on the New England tablelands and in far-east Gippsland in Victoria (DEC 2006u). It grows in moist woodland or forest on clay and alluvial soils of floodplains and creeklines (DEC 2006u).

There are no records of this species on the Muswellbrook 1:100,000 Map Sheet, and it is unlikely that the area covered by this sheet is an important area for this species. A dubious record for this species exists at Camerons Gorge Nature Reserve, near Scone (Peake 2006). Despite extensive seasonal surveys, this species was not recorded within the Study Area, and it is considered unlikely that potential habitat exists for this species within the Study Area, or in the immediate locality.

***Pterostylis gibbosa* –** is currently known from five locations: three sites in the Illawarra; one site near Nowra in the Shoalhaven; and one site at Milbrodale in the Hunter Valley. All known sub-populations of *P. gibbosa* occur in open forest or woodland on flat or gently sloping land with poorly drained soils (DEC 2006v). The Milbrodale sub-population of *P. gibbosa* occurs at an elevation of 150 to 160 metres ASL on soils derived from Triassic sedimentary rocks of the Narrabeen group (DEC 2006v).

There are no records of this species on the Muswellbrook 1:100,000 Map Sheet, and it is unlikely that the area covered by this sheet is an important area for this species. Despite extensive seasonal surveys, this species was not recorded within the Study Area, and it is considered unlikely that potential habitat exists for this species within the Study Area, or in the immediate locality.

***Rulingia procumbens* –** Confined to the Dubbo-Mendooran-Gilgandra region, and also the Pilliga and Nymagee regions (DEC 2006w). Botanical subdivisions this species is found in include the Central West Slopes, North-western Plains and the South-western Plains (Harden 2000). In the Hunter Valley, the species was recorded from Manobalai vacant Crown land (Bell 1997) and Mount Dangar in Goulburn River NP (Bell 2001), although the specimens occurring at these sites have been reclassified as *Commersonia rosea*.

The preferred habitat of this species is sandy, gravelly soil with good drainage and full sun. *Rulingia procumbens* has adaptations which enables it to survive in marginal environments, such as the ability to store water in its underground root tubers (Western Conservation Alliance 2002).

There are two records of this species on the Muswellbrook 1:100,000 Map Sheet, these being from the Sandy Hollow area, to the west of the Study Area, although, as mentioned above, these are now known to be *Commersonia rosea*.

Despite extensive seasonal surveys, this species was not recorded within the Study Area, and it is considered unlikely that potential habitat exists for this species within the Study Area, or in the immediate locality.

***Senecio linearifolius* var. *dangarensis* –** is restricted to a single known population at Mount Dangar in Goulburn River National Park where it has been recorded growing on an open scree slope (Thompson 2004) and in woodland and rainforest communities on basalt (Hill 1999).

There are no records of this species on the Muswellbrook 1:100,000 Map Sheet, and it is unlikely that the area covered by this sheet is an important area for this species. Despite extensive seasonal surveys, this species was not recorded within the Study Area, and it is considered unlikely that potential habitat exists for this species within the Study Area, or in the immediate locality.

***Wollemia nobilis* - Wollemi pine –** this species is restricted to a deep gorge within Wollemi National Park, north-west of Sydney (DEC 2006x). The sandstone ridges and gorge walls are dominated by dry sclerophyll woodland and shrubland. An area of warm temperate rainforest in the deep gorge is dominated by coachwood (*Ceratopetalum apetalum*) and sassafras (*Sassafras doryphora*), with an understorey dominated by ferns such as sticherus (*Sticherus flabellatus*). The Wollemi pines grow on ledges in these canyons (DEC 2006x).

There are no records of this species on the Muswellbrook 1:100,000 Map Sheet, and it is unlikely that the area covered by this sheet is an important area for this species. Despite extensive seasonal surveys, this species was not recorded within the Study Area, and it is considered unlikely that potential habitat exists for this species within the Study Area, or in the immediate locality.

4.6 Likelihood for Endangered Ecological Communities

Apart from one EEC that has been identified in the Study Area, two further communities (one listed under the TSC Act 1995 only, the other listed under both the TSC Act 1995 and the EPBC Act 1999) were regarded as having the potential to occur in the Study Area. Neither community is present, the reasons for which are presented below.

4.6.1 Hunter Lowlands Redgum Forest

Hunter Lowlands Redgum Forest is a highly variable forest or woodland community that occurs generally between Muswellbrook, Beresfield, Mulbring and Cessnock (Peake 2006). It is typically dominated by forest red gum (*Eucalyptus tereticornis*), grey gum (*Eucalyptus punctata*), narrow-leaved ironbark (*Eucalyptus crebra*) and rough-barked apple (*Angophora floribunda*) (NPWS 2000a). Grey box (*Eucalyptus moluccana*) is an important tree species, particularly in the western and central parts of its range, and even in the western parts of Maitland and Cessnock LGAs (Peake 2006).

A shrub stratum is sometimes present and is usually sparse but may be mid-dense at times, while the community is usually characterised by a grassy understorey, whether through natural circumstances or as a result of previous modification is not entirely clear (Peake 2006).

Hill (2003) recognised two variants in a survey of Maitland LGA, while Bell (2004) indicated that the vegetation community is highly variable, and that it can be difficult to define in some places. Peake (2006) regarded Muswellbrook as the extreme western occurrence of the community, and recommended that a regional survey and analysis of this community is required.

Peake (2006) indicated that Hunter Lowlands Redgum Forest generally occurs in open depressions and drainage flats on Permian sediments, and is usually associated with relatively minor creeklines.

The most likely vegetation communities in the Study Area that could potentially conform to Hunter Lowlands Redgum Forest are Forest Red Gum Riparian Woodland and Rough-barked Apple Woodland. An analysis of the diagnostic species list of Hunter Lowlands Redgum Forest (NPWS 2000a) was undertaken, using a comparison of the level of sharing of the key diagnostic species of NPWS (2000a) against those recorded in each of the two target vegetation communities as the basis upon which an assessment was made. In both cases, the target vegetation communities were much more similar to MU 13 Hunter Floodplain Red Gum Woodland Complex of the Hunter Remnant Vegetation Project (Peake 2006) than they were to Hunter Lowlands Redgum Forest.

Based on the above assessment, the Hunter Lowlands Redgum Forest EEC is not present in the Study Area.

4.6.2 White Box – Yellow Box – Blakely's Red Gum Woodland and White Box – Yellow Box – Blakely's Red Gum Grassy Woodland and Derived Native Grasslands

White Box – Yellow Box – Blakely's Red Gum Woodland is listed as an EEC under the TSC Act 1995, while White Box – Yellow Box – Blakely's Red Gum Grassy Woodland and Derived Native Grasslands is listed as an EEC under the EPBC Act 1999.

Peake (2006) mapped MU 11 Upper Hunter White Box – Ironbark Grassy Woodland broadly between Aberdeen and Wingen, north of Scone, but indicated that it occurred more extensively to the north of those areas. Peake (2006) indicated that this community more or less corresponded with White Box – Yellow Box – Blakely's Red Gum Woodland and White Box – Yellow Box – Blakely's Red Gum Grassy Woodland and Derived Native Grasslands, and should therefore be generally regarded as an EEC. As both of the EECs cover very broad geographical distributions, their characteristic species lists may not be highly indicative of the nature of those EECs where they occur at the margins of their ranges, such as in the Upper Hunter Valley. For this reason, a comparison of the vegetation communities in the Study Area against Peake's (2006) MU11 Upper Hunter White Box – Ironbark Grassy Woodland was made, as this community is indicative of the EECs.

MU 11 Upper Hunter White Box – Ironbark Grassy Woodland is a mid-high woodland with an open canopy dominated by narrow-leaved ironbark (*Eucalyptus crebra*), white box (*Eucalyptus albens*) or white box – grey box intergrade (*Eucalyptus albens—moluccana*) (Peake 2006). There may be a sparse shrubby understorey comprising kangaroo thorn (*Acacia paradoxa*), native olive (*Notelaea microcarpa* var. *microcarpa*), water bush (*Myoporum montanum*), western golden wattle (*Acacia decora*), eastern cottonbush (*Maireana microphylla*) and blackthorn (*Bursaria spinosa* subsp. *spinosa*), while the ground cover is moderately dense to dense, occasionally sparse, and dominated by grasses and herbs (Peake 2006).

Peake (2006) indicated that Upper Hunter White Box – Ironbark Grassy Woodland typically occurs on gently undulating slopes and hills which surround the floodplains of the upper Hunter, occurring on relatively low rainfall areas on clay and earth soils that are usually associated with Permian and Carboniferous geologies. Peake (2006) recognised a variant dominated by slaty box (*Eucalyptus dawsonii*) and a variant dominated by spotted gum (*Corymbia maculata*).

The most likely vegetation community in the Study Area that could potentially conform to White Box – Yellow Box – Blakely's Red Gum Woodland or White Box – Yellow Box – Blakely's Red Gum Grassy Woodland and Derived Native Grasslands is Forest Red Gum Riparian Woodland. An analysis of the diagnostic species list of Upper Hunter White Box – Ironbark Grassy Woodland (Peake 2006) was undertaken, using a comparison of the level of sharing of the key diagnostic species of Peake (2006) against those recorded in the target vegetation community as the basis upon which an assessment was made. The target vegetation community was much more similar to MU 13 Hunter Floodplain Red Gum Woodland Complex of the Hunter Remnant Vegetation Project (Peake 2006) than it was to Upper Hunter White Box – Ironbark Grassy Woodland.

Based on the above assessment, the White Box – Yellow Box – Blakely's Red Gum Woodland or White Box – Yellow Box – Blakely's Red Gum Grassy Woodland and Derived Native Grasslands are not present in the Study Area.

4.7 Likelihood for Endangered Flora Populations

Apart from the two endangered flora populations identified in the Study Area (see **Section 4.4.1**), only one other population was regarded as having the potential to occur: *Eucalyptus camaldulensis* in the Hunter Catchment. This population occurs throughout the alluvial flats of the Hunter Valley, predominantly between Scone, Denman and Singleton, but also as far east as Maitland, south to Broke and west to Bylong (Peake 2006). In the local area it is known to occur at Denman, Sandy Hollow and on Wybong Creek, approximately 4 kilometres south-west from the south-western part of the Study Area. Despite thorough surveys, no individuals of river red gum (*Eucalyptus camaldulensis*) were identified in the Study Area. Due to the lack of deep alluvium and the extensive searches undertaken, this endangered population is regarded as being absent from the Study Area.

5.0 Fauna Results

5.1 Fauna Species Recorded

A total of 188 fauna species were recorded within the Study Area during surveys undertaken by Umwelt, with 166 species being recorded within the Proposed Disturbance Area, while 179 species were recorded in the Proposed Offset Areas. An outline and discussion of the species recorded within each of the four major fauna groups is presented in the following sections.

A list of all fauna species recorded within the Study Area is presented in **Appendix H** of this report. This species list was compiled from data recorded during field surveys undertaken by Umwelt from 2004 to 2005, as well as records from previous HLA Envirosciences surveys of the Study Area. Only threatened species records from the Envirofund site (as reported by Abel Ecology 2005) are included in the list. Common species from that survey are not included, as none of these were recorded within the Study Area.

Records of fauna species should be interpreted carefully, since a record of a species within a particular area does not suggest it only occurs within that specific part of the Study Area, and not within other parts. The high levels of mobility of many fauna species (particularly many birds and mammals) mean that those species could readily occur in areas other than where they were recorded.

In addition to this, the mobility of many fauna species should be taken into account when interpreting population size (or abundance) of recorded species. This ability to travel throughout the Study Area would increase the possibility of recording the same individual within different parts of the Study Area. As it is not possible to readily distinguish between individuals, there is the potential for ‘double-counting’ of an individual. This would make the direct translation of number of records to a representation of population size inaccurate.

5.1.1 Birds

A total of 122 bird species were recorded in the Study Area during surveys undertaken by Umwelt, with 109 of these species recorded within the Proposed Disturbance Area and 114 species in the Proposed Offset Areas. There were 40 families represented in the Proposed Disturbance Area, and 42 in the Proposed Offset Areas. Families recording the highest species diversity within the Proposed Disturbance Area include the Pardalotidae (pardalotes) recording ten species, Artamidae (woodswallows) recording ten species and Meliphagidae (honeyeaters) recording seven species. Within the Proposed Offset Areas, the Pardalotidae (pardalotes) recorded 10 species, Meliphagidae (honeyeaters) recorded nine species and Pachycephalidae (whistlers and flycatchers) recorded six species. Raptor diversity was similar across both areas, with five Accipitridae and four Falconidae within the Proposed Disturbance Area and six Accipitridae and four Falconidae within the Proposed Offset Areas. Both areas recorded three introduced species, these being the common starling (*Sturnus vulgaris*), common myna (*Acridotheres tristis*) and the feral pigeon (*Columba livia*).

In the Proposed Disturbance Area, two listed migratory and 17 listed marine species were recorded (EPBC Act 1999). Comparatively, two migratory and 19 marine species were observed within the Proposed Offset Areas.

Some of the more frequently observed bird species recorded across the whole Study Area included the rufous whistler (*Pachycephala rufiventris*), galah (*Cacatua roseicapilla*), eastern rosella (*Platycercus eximius*), willie wagtail (*Rhipidura leucophrys*), rainbow bee-eater (*Merops ornatus*), yellow-rumped thornbill (*Acanthiza chrysorrhoa*), noisy friarbird (*Philemon corniculatus*), black-faced cuckoo-shrike (*Coracina novaehollandiae*), Australian magpie

(*Gymnorhina tibicen*), pied butcherbird (*Cracticus nigrogularis*), Australian raven (*Corvus coronoides*) and white-winged chough (*Corcorax melanorhamphos*).

There were nine raptor species recorded within the Proposed Disturbance Area and ten in the Proposed Offset Areas. This reasonably high diversity of raptor species indicates that prey species across the site are moderately abundant.

A wedge-tailed eagle (*Aquila audax*) nest with one fledgling was observed during surveys of the Proposed Disturbance Area in 2004. Other evidence of successful breeding occurring within the Study Area was limited to easily-identifiable nests, such as those from the willie wagtail (*Rhipidura leucophrys*) and white-winged choughs (*Corcorax melanorhamphos*). A number of other nests were observed, however it was not possible to identify the species responsible.

Six threatened bird species were recorded within both the Proposed Disturbance Area and Proposed Offset Areas, these being the diamond firetail (*Stagonopleura guttata*), speckled warbler (*Pyrrholaemus sagittata*), brown treecreeper (*Climacteris picumnus victoriae*), glossy black-cockatoo (*Calyptorhynchus lathami*), grey-crowned babbler (*Pomatostomus temporalis temporalis*) and hooded robin (*Melanodryas cucullata cucullata*). The turquoise parrot (*Neophema pulchella*) was the only threatened species recorded solely from the Proposed Disturbance Area. The masked owl (*Tyto novaehollandiae*) was the only species recorded solely from the Proposed Offset Areas.

5.1.2 Reptiles

During surveys undertaken by Umwelt, a total of 13 reptile species were recorded, with 9 reptiles recorded within the Proposed Disturbance Area, and 12 species in the Proposed Offset Areas. In the Proposed Disturbance Area, a total of six reptile families were recorded, with the skink family (Scincidae) being the most well represented. In comparison, five reptile families were represented from the Proposed Offset Areas, again with the skinks being the most abundant family.

No threatened reptile species were recorded in either the Proposed Disturbance Area or the Proposed Offset Areas. The most commonly encountered reptile species were (*Egernia modesta*) and the southern rainbow skink (*Carlia tetradactyla*).

5.1.3 Amphibians

A total of nine amphibian species were recorded within the Study Area, with nine species recorded from the Proposed Disturbance Area, and only four were observed in the Proposed Offset Areas. Two amphibian families were represented in both areas, these being Hylidae and Myobatrachidae. The two most common species recorded were the broad-palmed frog (*Litoria latopalmata*) and the brown froglet (*Crinia signifera*). No threatened or introduced amphibian species were recorded in either the Proposed Disturbance Area or Proposed Offset Areas.

5.1.4 Mammals

During surveys undertaken by Umwelt, a total of 44 mammal species were recorded within the Study Area, with 37 of these being recorded in the Proposed Disturbance Area, while 44 were recorded in the Proposed Offset Areas. In the Proposed Disturbance Area, 10 introduced mammal species were recorded, while nine were found in the Proposed Offset Areas. The most common family in both the Proposed Disturbance Area and Proposed Offset Areas were the Vespertilionidae bats, with nine and 14 species recorded respectively.

Four arboreal mammal species were observed within both areas, these being the squirrel glider, sugar glider (*Petaurus breviceps*) common ring-tailed possum (*Pseudocheirus peregrinus*) and common brush-tailed possum (*Trichosurus vulpecula*).

Several species of macropod were recorded within the Proposed Disturbance Area and Proposed Offset Areas, including the eastern grey kangaroo (*Macropus giganteus*), common wallaroo (*Macropus robustus*) and red-necked wallaby (*Macropus rufogriseus*), and also the swamp wallaby (*Wallabia bicolor*) which was only found in the Proposed Offset Areas. Each of these species, excepting the brush-tailed rock-wallaby, were principally observed in the open grassland areas, however, were also less frequently recorded in the forest and woodland communities. The brush-tailed rock-wallaby was identified from Proposed Offset Areas by analysis of scats located on the Limb of Addy Hill.

Six threatened mammal species were recorded within the Proposed Disturbance Area, these being the squirrel glider (*Petaurus norfolcensis*), eastern bentwing-bat (*Miniopterus schreibersii oceanensis*), large-eared pied bat (*Chalinolobus dwyeri*), large-footed myotis (*Myotis adversus*), greater broad-nosed bat *(Scoteanax rueppellii*) and the eastern cave bat (*Vespadelus troughtoni*). The Proposed Offset Areas has records of the koala (*Phascolarctos cinereus*), squirrel glider, brush-tailed rock-wallaby (*Petrogale penicillata*), eastern freetail-bat (*Mormopterus norfolkensis*), eastern bentwing-bat, eastern false pipistrelle (*Falsistrellus tasmaniensis*), large-eared pied bat, large-footed myotis and eastern cave bat.

5.2 Threatened Fauna Records

A detailed table of all potential threatened fauna species and endangered populations is provided in **Appendix A**. **Table 5.1** below lists the threatened fauna species from **Appendix A** considered to have potential habitat within the Study Area:

Table 5.1 – Threatened and Migratory Fauna Species with Potential Habitat in the Study Area

Species Name		Status	
Common name	**Scientific name**	**TSC Act 1995**	**EPBC Act 1999**
green and golden bell frog	*Litoria aurea*	E	V
pink-tailed legless lizard	*Aprasia parapulchella*	V	V
Rosenberg's goanna	*Varanus rosenbergi*	V	
pale-headed snake	*Hoplocephalus bitorquatus*	V	
broad-headed snake	*Hoplocephalus bungaroides*	E	V
square-tailed kite	*Lophoictinia isura*	V	
osprey	*Pandion haliaetus*	V	
red goshawk	*Erythrotriorchis radiatus*	E	V
grey falcon	*Falco hypoleucos*	V	
red-backed button-quail	*Turnix maculosa*	V	
bush stone-curlew	*Burhinus grallarius*	E	
gang gang cockatoo	*Callocephalon fimbriatum*	V	
red-tailed black-cockatoo	*Calyptorhynchus banksii*	V	E (south-east)
glossy black-cockatoo	*Calyptorhynchus lathami*	V	

Table 5.1 – Threatened and Migratory Fauna Species with Potential Habitat in the Study Area (cont)

Species Name		Status	
Common name	**Scientific name**	**TSC Act 1995**	**EPBC Act 1999**
superb parrot	*Polytelis swainsonii*	V	V
swift parrot	*Lathamus discolor*	E	E
turquoise parrot	*Neophema pulchella*	V	
powerful owl	*Ninox strenua*	V	
barking owl	*Ninox connivens*	V	
sooty owl	*Tyto tenebricosa*	V	
masked owl	*Tyto novaehollandiae*	V	
brown treecreeper	*Climacteris picumnus victoriae*	V	
regent honeyeater	*Xanthomyza phrygia*	E	E
black-chinned honeyeater	*Melithreptus gularis gularis*	V	
painted honeyeater	*Grantiella picta*	V	
speckled warbler	*Pyrrholaemus sagittata*	V	
hooded robin	*Melanodryas cucullata cucullata*	V	
grey-crowned babbler	*Pomatostomus temporalis temporalis*	V	
olive whistler	*Pachycephala olivacea*	V	
diamond firetail	*Stagonopleura guttata*	V	
rainbow bee-eater	*Merops ornatus*		Marine
cicadabird	*Coracina tenuirostris*		M
cattle egret	*Ardea ibis*		Marine
great egret	*Ardea alba*		Marine
white-bellied sea-eagle	*Haliaeetus leucogaster*		Marine
white-throated needletail	*Hirundapus caudacutus*		Marine
black-faced monarch	*Monarcha melanopsis*		Marine
satin flycatcher	*Myiagra cyanoleuca*		Marine
swift parrot	*Lathamus discolor*	E	E Marine
regent honeyeater	*Xanthomyza phrygia*	E	E M
fork-tailed swift	*Apus pacificus*		Marine
spotted-tailed quoll	*Dasyurus □aculates maculatus*	V	E
brush-tailed phascogale	*Phascogale tapoatafa*	V	
common planigale	*Planigale maculata*	V	
koala	*Phascolarctos cinereus*	V	
eastern pygmy possum	*Cercartetus nanus*	V	
squirrel glider	*Petaurus norfolcensis*	V	
brush-tailed rock-wallaby	*Petrogale penicillata*	E	V
grey-headed flying-fox	*Pteropus poliocephalus*	V	V
yellow-bellied sheathtail bat	*Saccolaimus flaviventris*	V	
eastern freetail-bat	*Mormopterus norfolkensis*	V	
eastern bentwing-bat	*Miniopterus schreibersii oceanensis*	V	
greater long-eared bat	*Nyctophilus timoriensis*	V	V

Table 5.1 – Threatened and Migratory Fauna Species with Potential Habitat in the Study Area (cont)

Species Name		Status	
Common name	**Scientific name**	**TSC Act 1995**	**EPBC Act 1999**
little pied bat	*Chalinolobus picatus*	V	
eastern false pipistrelle	*Falsistrellis tasmaniensis*	V	
large-eared pied bat	*Chalinolobus dwyeri*	V	V
large-footed myotis	*Myotis adversus*	V	
greater broad-nosed bat	*Scoteanax rueppellii*	V	
eastern cave bat	*Vespadelus troughtoni*	V	

Key: E = Endangered
V = Vulnerable
M = Migratory
Marine = Marine Overfly

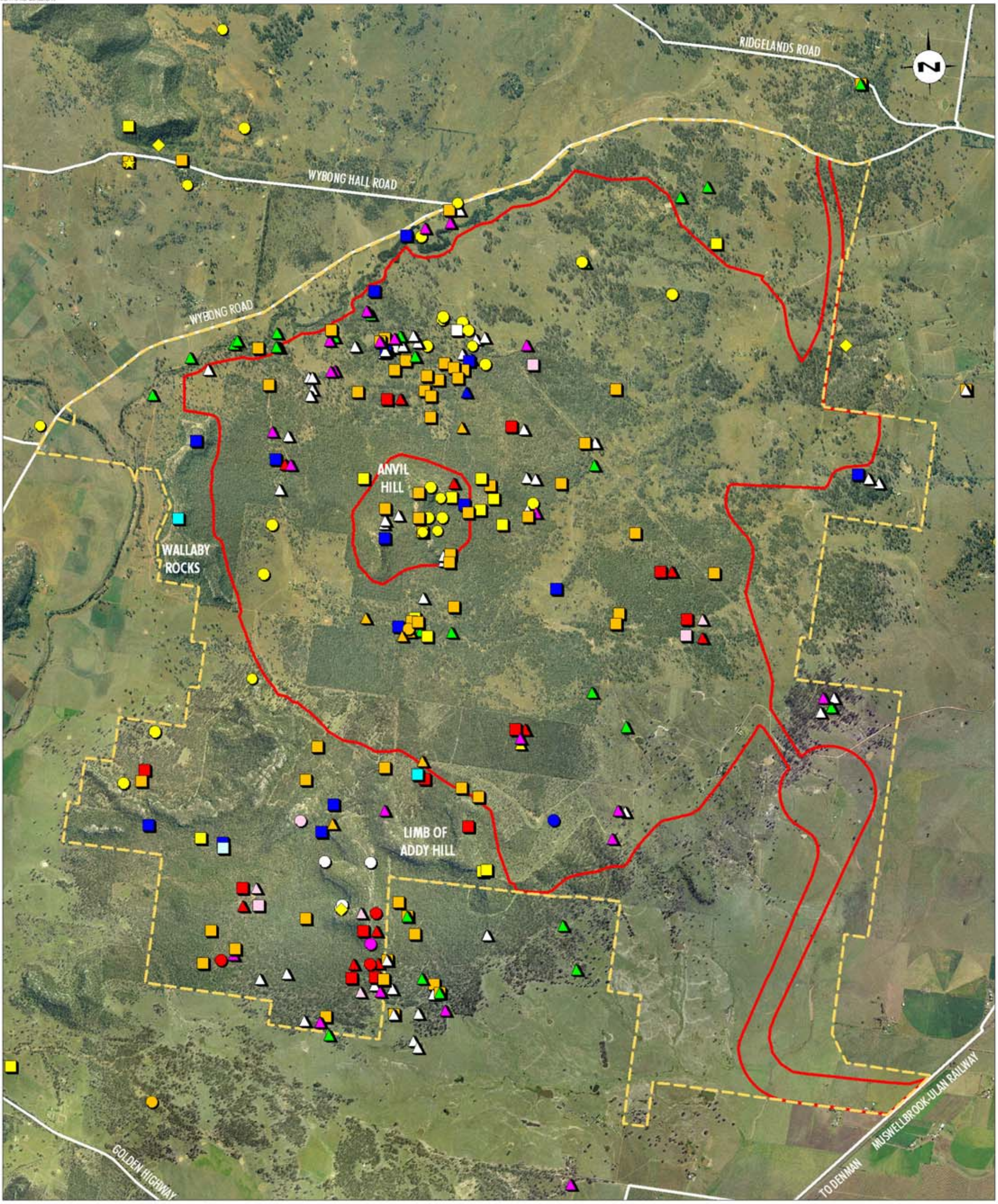
Not all data sources provide sufficient information to allow records to be mapped, however threatened species records from reliable sources are included within the species lists provided in **Appendix H**. The following sources provide threatened species records with co-ordinate data, allowing them to be mapped:

- a 20 kilometre radius search from the centre of the Study Area from the DEC Atlas of NSW Wildlife Muswellbrook 1:100,000 Map Sheet (February 2006);
- field survey results from HLA Envirosciences (2001 and 2002);
- field survey results from Umwelt (2004 and 2005);
- Birds Australia database searches for 20 kilometre radius of the centre of the Study Area (February 2006); and
- Australian Museum database searches for 20 kilometre radius of the centre of the Study Area (February 2006).

Figure 5.1 shows mapping of all threatened and migratory species records from within the Study Area, where sufficient information was available. The following **Table 5.2** documents the total number of records for each species, regardless of the record source.

Table 5.2 – Records of Threatened and Migratory Fauna in the Study Area

	TSC Act 1995	**EPBC Act 1999**	**Total Number of Records**	**Proposed Disturbance Area**	**Proposed Offset Areas**
glossy black-cockatoo (*Calyptorhynchus lathami*)	V	-	13	8	5
turquoise parrot (*Neophema pulchella*)	V	-	1	1	0
powerful owl (*Ninox strenua*)	V	-	1	0	1



Source: Birds Australia (2006), DEC Atlas Of NSW Wildlife (2006), HCRCMA (1999), HLA Environsciences (2003), Australian Museum (2006)

Base Map: Dept. of Lands (2003), ortho-rectified by Plateau Images

Legend

- Proposed Disturbance Area
- Study Area

- Babbler nest
- Brown treecreeper
- Diamond firetail
- Glossy black-cockatoo
- Grey-crowned babbler
- Hooded robin
- Masked owl
- Painted honeyeater
- Powerful owl
- Rainbow bee-eater
- Satin flycatcher
- Speckled warbler
- Turquoise parrot
- White-bellied sea eagle
- White - throated needletail
- Brush-tailed rock-wallaby scat
- Koala scats
- Squirrel glider
- Eastern bentwing-bat
- Eastern cave bat
- Eastern freetail-bat
- Eastern false pipistrelle
- Greater broad-nosed bat
- Large-eared pied bat
- Large-footed myotis

FIGURE 5.1

Threatened and Migratory Fauna Locations

Table 5.2 – Records of Threatened and Migratory Fauna in the Study Area (cont)

	TSC Act 1995	EPBC Act 1999	Total Number of Records	Proposed Disturbance Area	Proposed Offset Areas
masked owl (*Tyto novaehollandiae*)	V	-	1	0	1
brown treecreeper (*Climacteris picumnus victoriae*)	V	-	45	30	15
speckled warbler (*Pyrrholaemus sagittata*)	V	-	50	32	18
hooded robin (*Melanodryas cucullata cucullata*)	V	-	22	14	8
grey-crowned babbler (*Pomatostomus temporalis temporalis*)	V	-	22	11	11
diamond firetail (*Stagonopleura guttata*)	V	-	20	12	8
koala (*Phascolarctos cinereus*)	V	-	1	0	1
squirrel glider (*Petaurus norfolcensis*)	V	-	6	5	1
brush-tailed rock-wallaby (*Petrogale penicillata*)	E	V	4	0	4
eastern freetail-bat (*Mormopterus norfolkensis*)	V	-	3	0	3
eastern bentwing-bat (*Miniopterus schreibersii oceanensis*)	V	-	12	5	7
eastern false pipistrelle (*Falsistrellus tasmaniensis*)	V	-	2	0	2
large-eared pied bat (*Chalinolobus dwyeri*)	V	V	4	1	3
large-footed myotis (*Myotis adversus*)	V	-	3	2	1
greater broad-nosed bat (*Scoteanax rueppellii*)	V	-	1	1	0
eastern cave bat (*Vespadelus troughtoni*)	V	-	10	5	5

Table 5.2 – Records of Threatened and Migratory Fauna in the Study Area (cont)

	TSC Act 1995	EPBC Act 1999	Total Number of Records	Proposed Disturbance Area	Proposed Offset Areas
rainbow bee-eater (*Merops ornatus*)	-	M	16	7	9
white-bellied sea-eagle (*Haliaeetus leucogaster*)	-	M	1	1	0
white-throated needletail (*Hirundapus caudacutus*)	-	M	1	0	1
satin flycatcher (*Myiagra cyanoleuca*)	-	M	1	1	0

A total of 19 fauna species listed as threatened under the TSC Act 1995 have been recorded in the Study Area. This number includes two species also listed as Vulnerable under the EPBC Act 1999. In addition to this, 4 migratory species as listed under the EPBC Act 1999 were recorded within the Study Area.

Detailed Tests of Significance for each recorded threatened species are provided within **Appendix F** for those species listed under the TSC Act 1995, and in **Appendix G** for those species listed under the EPBC Act 1999. Included in these assessments are those species that are considered to have potential habitat within the Study Area, but were not recorded during surveys.

5.2.1 Recorded Threatened Species

The following threatened species (as listed under the TSC Act 1995 and EPBC Act 1999) were recorded within the Study Area either as part of the current survey, or from other sources such as previous surveys, databases searches or literature reviews.

Details of the number and locations of these records, as well as any relevant ecological information relating to these records are provided below, as well as an assessment of the amount of known habitat (defined as vegetation communities in which each species was recorded) that will require removal as part of the proposal. It is important to note that this assessment includes only the communities from which the species was recorded. One recognised limitation of this assessment is that there is the potential for the species to occur within other communities of the Study Area. However, this assessment is based on records that came from field surveys conducted by Umwelt (2004 and 2005) and HLA Envirosciences (2001 and 2002).

5.2.1.1 Glossy black-cockatoo - *Calyptorhynchus lathami*

The glossy black-cockatoo (*Calyptorhynchus lathami*) is uncommon although widespread throughout suitable forest and woodland habitats, from the central Queensland coast to East Gippsland in Victoria, and inland to the southern tablelands and central western plains of NSW, with a small population in the Riverina (DEC 2006y). An isolated population exists on Kangaroo Island, South Australia. The species inhabits open forest and woodlands of the coast and the Great Dividing Range up to 1000 metres in which stands of sheoak species, particularly black sheoak (*Allocasuarina littoralis*), forest sheoak (*Allocasuarina torulosa*) or drooping sheoak (*Allocasuarina verticillata*) occur (DEC 2006y). In the Riverina area it inhabits open woodlands dominated by belah (*Casuarina cristata*) (DEC 2006y). They are usually seen in pairs or small groups feeding quietly in sheoaks, where they feed almost exclusively on the seeds of several species of sheoak (*Casuarina* and *Allocasuarina* species), shredding the cones with the massive bill (DEC 2006y). This species can be highly selective in its choice of food trees, choosing *Allocasuarina* species that produce seeds with a high nutrient value. They will also eat seeds from eucalypts, angophoras, acacias, cypress pine and hakeas, as well as eating insect larvae (NSW NPWS 1999a). This species is dependent on large hollow-bearing eucalypts for nest sites. One or two eggs are laid between March and August.

The glossy black-cockatoo was recorded on nine occasions during the Umwelt and HLA Envirosciences survey periods, at sites located within the Ironbark Woodland Complex, Bulloak Woodland, Drooping Sheoak Woodland and Forest Red Gum Riparian Woodland of the Proposed Disturbance Area, and within the Ironbark Woodland Complex, Slaty Box Woodland, Coast Myall Exposed Woodland and Sheltered Grey Gum Woodland of the Proposed Offset Areas. Vegetation community mapping within the Study Area has identified a total of 2227 hectares of these vegetation communities. Of this, 1283 hectares are located within the Proposed Disturbance Area, with the remaining 944 hectares located within the Proposed Offset Areas. On the basis of vegetation formations, this species was recorded from the Woodland and Riparian/Floodplain formations of the Proposed Disturbance Area, and the Woodland and Shrubland formations of the Proposed Offset Areas. The Study Area contains a total of 2336 hectares of these formations. Of this, 1304 hectares are located within the Proposed Disturbance Area, with the remaining 1032 hectares being located within the Proposed Offset Areas. There is the potential that this species could occur within other vegetation communities and formations within the Study Area.

5.2.1.2 Turquoise parrot - *Neophema pulchella*

The turquoise parrot's (*Neophema pulchella*) range extends from southern Queensland through to northern Victoria, from the coastal plains to the western slopes of the Great Dividing Range (DEC 2006z). The turquoise parrot occupies a variety of habitats, primarily eucalypt woodland and open forest near open water and forested hills. Also found in coastal heath, pasture, roadsides and orchards (Pizzey & Knight 1997). Habitat typically has a dense ground cover and a low understorey of shrubs (NSW NPWS 1999b), where the species feeds primarily on seeds, but may also utilise flowers, nectar, fruits, leaves and scale insects (NSW NPWS 1999b). This species is known to forage in white box (*Eucalyptus albens*), yellow box (*Eucalyptus melliodora*), Blakely's red gum (*Eucalyptus blakelyi*), *Leucopogon microphyllus, Dillwynia* spp., and the introduced sea barley grass (*Hordeum marinum),* saffron thistle *(Carthamnus lanatus)* and small nettle (*Urtica urens*) (NSW NPWS 1999b). They are usually seen in pairs or small, possibly family, groups and have also been reported in flocks of up to thirty individuals. The species prefers to feed in the shade of a tree and spends most of the day on the ground searching for the seeds or grasses and herbaceous plants, or browsing on vegetable matter (DEC 2006z). Breeds August to December and April to May (Pizzey & Knight). The nest is built in a hollow of a small tree, a stump, fence post or even a hollow log on the ground.

The turquoise parrot was recorded on one occasion during the Umwelt and HLA Envirosciences survey periods, being located within the Forest Red Gum Riparian Woodland within the Proposed Disturbance Area, to the south of Anvil Hill. Vegetation community mapping within the Study Area has identified a total of 51 hectares of this vegetation community. All of this vegetation community is located within the Proposed Disturbance Area. On the basis of vegetation formations, this species was only recorded within the Riparian/Floodplain formation. There is a total of 84 hectares of this formation within the Study Area. Of this, 53 hectares is located within the Proposed Disturbance Area, with the remaining 31 hectares being located within the Proposed Offset Areas. There is the potential that this species could occur within other vegetation communities and formations within the Study Area.

5.2.1.3 Powerful owl – *Ninox strenua*

The powerful owl (*Ninox strenua*) occurs in eastern Australia, mostly on the coastal side of the Great Dividing Range, from south-western Victoria to Bowen in Queensland (Garnett & Crowley 2000). In NSW, it is widely distributed throughout the eastern forests from the coast inland to tablelands, with scattered, mostly historical records on the western slopes and plains. Now uncommon throughout its range where it occurs at low densities (DEC 2006aa). This species inhabits a variety of woodland and open forest habitats, including relatively urbanised sites. The majority of records of this species are from within (or one kilometre from) extensively forested areas, usually on publicly owned land (Kavanagh 2002a). The powerful owl requires large tracts of forest or woodland habitat but can also occur in fragmented or urban landscapes (DEC 2006aa). It roosts by day in dense vegetation comprising species such as turpentine (*Syncarpia glomulifera* subsp*. glomulifera*), black sheoak (*Allocasuarina littoralis*), blackwood (*Acacia melanoxylon*), rough-barked apple (*Angorphora floribunda*), cherry ballart (*Exocarpus cupressiformis*) and a number of eucalypt species (DEC 2006aa). As most prey species require hollows and a shrub layer, these are important habitat components for the owl. This species will defend a large home range of between 800 and 1000 hectares (Kavanagh 2002a) and feeds mainly on a variety of arboreal marsupials, supplementing with large diurnal birds. It takes few or no ground-dwelling mammals (Kavanagh 2002a). Nests are made in large hollows (at least 0.5 metre deep), in large eucalypts (diameter at breast height of 80-240 cm) that are at least 150 years old (DEC 2006aa). Such trees are usually near riparian zone forest or minor drainage lines. Powerful owls show high nest tree fidelity in successive breeding seasons (Kavanagh 2002a). Nesting occurs from late autumn to mid-winter, but is slightly earlier in north-eastern NSW (late summer - mid autumn) (DEC 2006aa). Pairs are monogamous, and pair for life (DEC 2006aa). The pair is most vocal when nesting (Debus 1995).

The record of the powerful owl was obtained from the Hunter-Central Rivers Catchment Management Authority (Peake 2006), where an individual was accidentally flushed from a cave on the western face of the Limb of Addy Hill in the Proposed Offset Areas. This record was from the Tall Mixed Shrubland Complex. Vegetation community mapping within the Study Area has identified a total of 52 hectares of this vegetation community within the Study Area. All of this vegetation community is located within the Proposed Offset Areas. On the basis of vegetation formations, this species was recorded from the Shrubland formation of the Proposed Offset Areas. The Study Area contains a total of 127 hectares of this formation, all of which is located within the Proposed Offset Areas. There is the potential that this species could occur within other vegetation communities and formations within the Study Area. A second record of this species was reported by Abel Ecology (2005), where a record was obtained outside of the Study Area, although close to the boundary in the north-eastern corner. This part of the Study Area is dominated by fragmented Ironbark Woodland Complex surrounded with Disturbed Grassland.

5.2.1.4 Masked owl - *Tyto novaehollandiae*

The masked owl (*Tyto novaehollandiae*) occurs sparsely throughout the continent and nearby islands, including Tasmania and New Guinea (Kavanagh 2002a). Its distribution extends from the coast where it is most abundant to the western plains (DEC 2006ab). This species is generally recorded from open forest habitat with a sparse mid-storey and patches of dense, low ground cover. It is also recorded from ecotones between wet and dry eucalypt forest, along minor drainage lines and near boundaries between forest and cleared land (Kavanagh 2004). Home range estimates vary between 800 and 1200 hectares (Kavanagh 2002a). Masked owls nest (and roost) in large hollows of old trees and they also roost among dense foliage in variety of sub-canopy trees (Kavanagh 2004). They have been recorded nesting and roosting in caves. *Tyto* species have a variable breeding season (likely to be in response to prey fluctuations), however are most likely to breed in autumn or winter (Kavanagh 2002a). Masked owls commonly prey on small terrestrial and scansorial mammals, occasionally supplementing with diurnal birds (Kavanagh 2002b).

The masked owl was recorded on one occasion during the Umwelt and HLA Envirosciences survey periods, being located within the Ironbark Woodland Complex within the Proposed Offset Areas. Vegetation community mapping within the Study Area has identified a total of 1393 hectares of this vegetation community within the Study Area. Of this, 886 hectares is located within the Proposed Disturbance Area, with the remaining 507 hectares located within the Proposed Offset Areas. On the basis of vegetation formations, this species was only recorded from the Woodland formation. There is a total of 2125 hectares of this formation within the Study Area. Of this, 1251 hectares are located within the Proposed Disturbance Area, while the remaining 874 hectares are located within the Proposed Offset Areas. There is the potential that this species could occur within other vegetation communities and formations within the Study Area.

5.2.1.5 Brown treecreeper - *Climacteris picumnus victoriae*

The brown treecreeper (*Climacteris picumnus victoriae*) is endemic to eastern Australia and occurs in eucalypt forests and woodlands of inland plains and slopes of the Great Dividing Range. It is less commonly found on coastal plains and ranges (DEC 2006ac). The western boundary of the range of the brown treecreeper runs approximately through Wagga Wagga, Temora, Forbes, Dubbo and Inverell and along this line the subspecies intergrades with the arid zone subspecies of brown treecreeper (*Climacteris picumnus picumnus)* (DEC 2006ac). This species occurs over central NSW, west of the Great Dividing Range and sparsely scattered to the east of the divide in drier areas such as the Cumberland Plain of Western Sydney, and in parts of the Hunter, Clarence, Richmond and Snowy River valleys (NSW Scientific Committee 2001a). It is found in eucalypt woodlands (including Box-Gum Woodland) and dry open forest of the inland slopes and plains, where it mainly inhabits woodlands dominated by stringybarks or other rough-barked eucalypts, usually with an open grassy understorey, sometimes with one or more shrub species. It is also found in mallee and river red gum (*Eucalyptus camaldulensis*) forest bordering wetlands with an open understorey of acacias, saltbush, lignum, cumbungi and grasses but is usually not found in woodlands with a dense shrub layer. Fallen timber is an important habitat component for foraging. It is also recorded, though less commonly, in similar woodland habitats on the coastal ranges and plains (DEC 2006ac). This species is sedentary, territorial year-round, although some birds may disperse locally after breeding (DEC 2006ac). It is gregarious and is usually observed in pairs or small groups of eight to 12 birds; it is active, noisy and conspicuous while foraging on trunks and branches of trees and amongst fallen timber. This species is known to spend more time foraging on the ground and fallen logs than other treecreepers (DEC 2006ac). Hollows in standing dead or live trees and tree stumps are essential for nesting. The species breeds in pairs or co-operatively in territories which range in size from 1.1 to 10.7 hectares (mean = 4.4 hectares). Each group is composed of a breeding pair with retained male offspring and, rarely, retained female offspring. Breeding can be cooperative in this species, with groups of two to five birds participating. This species is highly sensitive to habitat fragmentation, with disrupted dispersal due to habitat isolation being the primary threat (Walters et al. 1999). Major declines of this species have occurred in remnant vegetation fragments smaller than 300 hectares that have been isolated or fragmented for more than 50 years (DEC 2006ac).

The brown treecreeper was recorded on 32 occasions during the Umwelt and HLA Envirosciences survey periods, being located within the Slaty Box Woodland, Ironbark Woodland Complex and Forest Red Gum Riparian Woodland of the Proposed Disturbance Area, and the Slaty Box Woodland, Ironbark Woodland Complex, Sheltered Grey Gum Woodland and Forest Red Gum Riparian Woodland within the Proposed Offset Areas.

Vegetation community mapping within the Study Area has identified a total of 2050 hectares of these vegetation communities within the Study Area. Of this, 1183 hectares is located within the Proposed Disturbance Area, with the remaining 868 hectares located within the Proposed Offset Areas. On the basis of vegetation formations, this species was recorded from the Woodland and Riparian/Floodplain formations within the Proposed Disturbance Area and the Woodland and Riparian/Floodplain formation within the Proposed Offset Areas. The Study Area contains a total of 2209 hectares of these formations. Of this, 1304 hectares are located within the Proposed Disturbance Area, with the remaining 905 hectares being located within the Proposed Offset Areas. There is the potential that this species could occur within other vegetation communities and formations within the Study Area.

5.2.1.6 Speckled warbler - *Pyrrholaemus sagittata*

The speckled warbler (*Pyrrholaemus sagittata*) has a distribution from south-eastern Queensland, through central and eastern NSW to Victoria. In NSW, this species occupies eucalypt and cypress woodlands, generally on the western slopes of the Great Dividing Range. It is rarely recorded from coastal areas (DEC 2006ad). It inhabits woodlands with a grassy understorey, leaf litter and shrub cover, often on ridges or gullies (Garnett & Crowley 2000). This species has also been recorded in cypress woodlands of the northern Riverina and in drier coastal areas such as the Cumberland Plain, Western Sydney and the Hunter and Snowy River valleys (NSW Scientific Committee 2001b). Typical habitat for this species would include scattered native tussock grasses, a sparse shrub layer, some eucalypt regrowth and an open canopy (DEC 2006ad). The species is sedentary, living in pairs or trios and nests on the ground in grass tussocks, dense litter and fallen branches. Home ranges vary from 6-12 hectares (NSW Scientific Committee 2001b). The nest is located in a slight hollow in the ground or the base of a low dense plant, often among fallen branches and other litter (DEC 2006ad). Breeding occurs between August and January, with cooperative breeding occasionally occurring (DEC 2006ad). Barrett et al. (1994) found that the species decreased in abundance as woodland area decreased, and it appears to be extinct in districts where no fragments larger than 100 hectares remain. Speckled warblers often join mixed species feeding flocks in winter, with other species such as the yellow-rumped thornbill (*Acanthiza chrysorrhoa*), buff-rumped thornbill (*Acanthiza reguloides*), brown thornbill (*Acanthiza pusilla*) and striated thornbill (*Acanthiza lineata*) (DEC 2006ad).

The speckled warbler was recorded on 32 occasions during the Umwelt and HLA Envirosciences survey periods, being located within the Ironbark Woodland Complex, Forest Red Gum Riparian Woodland, Slaty Box Woodland and Swamp Oak Riparian Forest within the Proposed Disturbance Area, and the Slaty Box Woodland, Ironbark Woodland Complex, Coast Myall Exposed Woodland, Rough-barked Apple Woodland and Drooping Sheoak Woodland within the Proposed Offset Areas. Vegetation community mapping within the Study Area has identified a total of 2080 hectares of these vegetation communities within the Study Area. Of this, 1185 hectares is located within the Proposed Disturbance Area, with the remaining 895 hectares located within the Proposed Offset Areas. On the basis of vegetation formations, this species was recorded from the Woodland and Riparian/Floodplain formations of the Proposed Disturbance Area, and the Woodland, Shrubland and Riparian/Floodplain formations within the Proposed Offset Areas. The Study Area contains a total of 2336 hectares of these formations. Of this, 1304 hectares are located within the Proposed Disturbance Area, with the remaining 1032 hectares being located within the Proposed Offset Areas. There is the potential that this species could occur within other vegetation communities and formations within the Study Area.

5.2.1.7 Hooded robin - *Melanodryas cucullata cucullata*

The species is widespread, found across Australia, except for the driest deserts and the wetter coastal areas in northern and eastern coastal Queensland and Tasmania (DEC 2006ae). The south-eastern form of the hooded robin (*Melanodryas cucullata cucullata*) is found from Brisbane to Adelaide throughout much of inland NSW, with the exception of the north-west. This form occurs throughout NSW except for the north-west, where it intergrades with the northern form *Melanodryas cucullata picata* (NSW Scientific Committee 2001c). It prefers lightly wooded country, usually open eucalypt woodland, acacia scrub and mallee, often in or near clearings or open areas. Hooded robins require structurally diverse habitats featuring mature eucalypts, saplings, some small shrubs and a ground layer of moderately tall native grasses (DEC 2006ae). They often perch on low dead stumps and fallen timber or on low-hanging branches, using a perch-and-pounce method of hunting insect prey. It is considered to be a sedentary species, with relatively large home ranges (ranging from 10 hectares during the breeding season, to 30 hectares in the non-breeding season) but local seasonal movements are possible (DEC 2006). This species may breed any time between July and November, often rearing several broods (DEC 2006ae). Two females often cooperate in raising young (DEC 2006ae). Hooded robins appear unable to survive in remnants smaller than 100-200 hectares (NSW Scientific Committee 2001c).

The hooded robin was recorded on 11 occasions during the Umwelt and HLA Envirosciences survey periods, being located within the Slaty Box Woodland, Bulloak Woodland, Forest Red Gum Riparian Woodland and Ironbark Woodland Complex within the Proposed Disturbance Area and the Slaty Box Woodland and Tall Mixed Shrubland Complex within the Proposed Offset Areas. Vegetation community mapping within the Study Area has identified a total of 2123 hectares of these vegetation communities within the Study Area. Of this, 1282 hectares are located within the Proposed Disturbance Area, with the remaining 841 hectares located within the Proposed Offset Areas. On the basis of vegetation formations, this species was recorded from the Woodland and Riparian/Floodplain formations within the Proposed Disturbance Area, and the Woodland and Shrubland formations within the Proposed Offset Areas. The Study Area contains a total of 2336 hectares of these formations. Of this, 1304 hectares are located within the Proposed Disturbance Area, with the remaining 1032 hectares being located within the Proposed Offset Areas. There is the potential that this species could occur within other vegetation communities and formations within the Study Area.

5.2.1.8 Grey-crowned babbler - *Pomatostomus temporalis temporalis*

The grey-crowned babbler (*Pomatostomus temporalis temporalis*) is found throughout parts of northern Australia and south-eastern Australia. In NSW, the eastern sub-species occurs on the western slopes of the Great Dividing Range, and on the western plains reaching as far as Louth and Hay (DEC 2006af). It is less common on the higher tablelands (NSW Scientific Committee 2001e). It also occurs in woodlands in the Hunter Valley and in several locations on the north coast of NSW (DEC 2006af). This species inhabits open Box-Gum Woodlands on the slopes, and Box-Cypress-pine and open Box Woodlands on alluvial plains. It has been recorded from open forest and woodland, acacia scrubland and adjoining open areas (Garnett & Crowley 2000). This species is highly susceptible to habitat fragmentation (Garnett & Crowley 2000), as birds are generally unable to cross large open areas (DEC 2006af). This species lives in sedentary family groups that consist of a breeding pair and young from previous breeding seasons. A group may consist of up to fifteen birds. All members of the family group remain close to each other when foraging (DEC 2006af). It feeds on invertebrates, either by foraging on the trunks and branches of eucalypts and other woodland trees or on the ground, digging and probing amongst litter and tussock grasses (DEC 2006af). This species will build and maintain several conspicuous, dome-shaped stick nests, which are used as dormitories for roosting each night. Nests are usually located in shrubs or sapling eucalypts, although they may be built in the outermost leaves of low branches of large eucalypts. Nests are maintained year round, and old nests are often dismantled to build new ones (DEC 2006af). This species breeds between July and February. Young birds are fed by all members of the group (DEC 2006af). Territories range from one to fifty hectares (usually around ten hectares) and are defended all year (DEC 2006af).

The grey-crowned babbler was recorded on 11 occasions during the Umwelt and HLA Envirosciences survey periods. In addition to this, two babbler nests were recorded. The records of this species were located within the Slaty Box Woodland (birds and nest recorded), Forest Red Gum Riparian Woodland (nest only) and Ironbark Woodland Complex (birds only) within the Proposed Disturbance Area, and the Swamp Oak Riparian Forest (birds only), Slaty Box Woodland (birds only), Ironbark Woodland Complex (birds only), Coast Myall Exposed Woodland (birds only) and Sheltered Grey Gum Woodland (birds only) within the Proposed Offset Areas. Vegetation community mapping within the Study Area has identified a total of 2145 hectares of these vegetation communities within the Study Area. Of this, 1184 hectares are located within the Proposed Disturbance Area, with the remaining 962 hectares located within the Proposed Offset Areas. On the basis of vegetation formations, this species was recorded from the Woodland and Riparian/Floodplain formations of the Proposed Disturbance Area, and the Riparian/Floodplain, Woodland and Shrubland formations within the Proposed Offset Areas. The Study Area contains a total of 2336 hectares of these formations. Of this, 1304 hectares are located within the Proposed Disturbance Area, with the remaining 1032 hectares being located within the Proposed Offset Areas. There is the potential that this species could occur within other vegetation communities and formations within the Study Area.

5.2.1.9 Painted honeyeater - *Grantiella picta*

This species has a sparse distribution ranging from south-eastern Australia to north-western Queensland and eastern Northern Territory (Garnett & Crowley 2000). The greatest concentrations of records of this species (including almost all breeding records) occur on the inland slopes of the Great Dividing Range in NSW, Victoria and southern Queensland (DEC 2006ag). The painted honeyeater (*Grantiella picta*) is nomadic and occurs at low densities throughout its range (DEC 2006ag). In southern areas, this species migrates north to semi-arid regions in South Australia, and northern Australia after April. Typical habitat for this species includes Boree, Brigalow and Box-Gum Woodlands and Box-Ironbark Forests (DEC 2006ag), particularly those with high concentrations of mistletoes (mainly *Amyema* spp.). It feeds almost exclusively on mistletoe berries, however will take nectar and insects occasionally (Garnett & Crowley 2000). Breeding distribution is often dictated by the presence of suitable mistletoes. Generally, it will nest from spring to autumn in a small, delicate nest hanging within the outer canopy of drooping eucalypts, sheoak, paperbark or mistletoe branches (DEC 2006ag).

The record of the painted honeyeater came from searches of the DEC Atlas of NSW Wildlife (2006ag). No further records of this species were identified, despite detailed surveys throughout the Study Area. This species was recorded outside of the Study Area, within the Ironbark Woodland Complex immediately north of Wybong Hall Road. This is the most extensive vegetation community within the Study Area, and is likely to provide habitat for this species wherever the community occurs within the Study Area. There is the potential that this species could occur within other vegetation communities and formations within the Study Area.

5.2.1.10 Diamond firetail - *Stagonopleura guttata*

The diamond firetail (*Stagonopleura guttata*) is widely distributed in NSW, with a concentration of records from the Northern, Central and Southern Tablelands, the Northern, Central and South Western Slopes and the North West Plains and Riverina. It is not commonly found in coastal districts, though there are records from near Sydney, the Hunter Valley and the Bega Valley. This species has a scattered distribution over the rest of NSW and is found in the Australian Capital Territory, Queensland, Victoria and South Australia (DEC 2006ah). Habitat includes a range of eucalypt-dominated communities with a grassy understorey, including woodland, forest and mallee (Garnett & Crowley 2000). It appears that populations are unable to persist in areas where there are no vegetated remnants larger than 200 hectares (NSW Scientific Committee 2001f). This species feeds exclusively on the ground, on ripe and partly-ripe grass and herb seeds and green leaves, and on insects (especially in the breeding season). Diamond firetails are usually encountered in flocks of between five to 40 birds, occasionally more. Groups separate into small colonies to breed, between August and January. Birds roost in dense shrubs or in smaller nests built especially for roosting. This species appears to be sedentary, though some populations move locally, especially those from southern areas (DEC 2006ah).

The diamond firetail was recorded on ten occasions during the Umwelt and HLA Envirosciences survey periods, being located within the Forest Red Gum Riparian Woodland, Ironbark Woodland Complex, Slaty Box Woodland and Swamp Oak Riparian Forest within the Proposed Disturbance Area, and the Slaty Box Woodland and Rough-barked Apple Woodland within the Proposed Offset Areas. Vegetation community mapping within the Study Area has identified a total of 2003 hectares of these vegetation communities within the Study Area. Of this, 1184 hectares are located within the Proposed Disturbance Area, with the remaining 819 hectares located within the Proposed Offset Areas. On the basis of vegetation formations, this species was recorded from the Riparian/Floodplain and Woodland formations within the Proposed Disturbance Area, and the Woodland and Riparian/Floodplain formations within the Proposed Offset Areas. The Study Area contains a total of 2209 hectares of these formations. Of this, 1304 hectares are located within the Proposed Disturbance Area, with the remaining 905 hectares being located in the Proposed Offset Areas. There is the potential that this species could occur within other vegetation communities and formations within the Study Area.

5.2.1.11 Koala - *Phascolarctos cinereus*

The koala (*Phascolarctos cinereus*) has a fragmented distribution throughout eastern Australia, with the majority of records from NSW occurring on the central and north coasts, as well as some areas further west (NSW NPWS 1999c). It is known to occur along inland rivers on the western side of the Great Dividing Range (NSW NPWS 1999c). This species inhabits eucalypt forest and woodland, with suitability influenced by tree species and age, soil fertility, climate, rainfall and fragmentation patterns (NSW NPWS 1999c). This species will feed on the foliage of more than 70 eucalypt species and 30 non-eucalypt species, but in any one area will select preferred browse species (DEC 2006ai). Home ranges vary considerably according to habitat quality, with an average of 10 to 15 hectares in the Pilliga State Forest to an average of 80 to 90 hectares in the Port Stephens area (NSW NPWS 1999c). Young are generally produced in summer, remaining with the mother for up to three years (NSW NPWS 1999c). Koalas spend most of their time in trees, but will descend and traverse open ground to move between trees (DEC 2006ai).

The koala was recorded on one occasion during the Umwelt and HLA Envirosciences survey periods from a single group of scats under one tree located within the Ironbark Woodland Complex of the Proposed Offset Areas. No koalas were observed and no further scats were found during surveys. Vegetation community mapping within the Study Area has identified a total of 1393 hectares of this vegetation community within the Study Area. Of this, 886 hectares are located within the Proposed Disturbance Area, with the remaining 507 hectares located within the Proposed Offset Areas. On the basis of vegetation formations, this species was recorded from the Woodland formation of the Proposed Offset Areas. There is a total of 2125 hectares of this formation within the Study Area. Of this, 1251 hectares are located within the Proposed Disturbance Area, with the remaining 874 hectares being located within the Proposed Offset Areas. There is the potential that this species could occur within other vegetation communities and formations within the Study Area. Further details and assessment of this species is provided within the SEPP 44 (Koala Habitat) Assessment in **Section 5.5** below.

5.2.1.12 Squirrel glider - *Petaurus norfolcensis*

The squirrel glider (*Petaurus norfolcensis*) is widely though sparsely distributed in eastern Australia, from northern Queensland to western Victoria (DEC 2006aj). This species generally inhabits dry sclerophyll forest and woodland, also being recorded from coastal and wet forests in the northern parts of NSW and Queensland (Suckling 2002). Preferred foraging habitat contains a regenerating understorey of eucalypts, wattles and flowering shrubs, allowing them to feed on arboreal invertebrates, eucalypt nectar, pollen and sap, and the seeds and gum of acacia species (NSW Scientific Committee 2000g). Winter flowering species such as red ironbark, spotted gum and coast banksia are particularly important when other food sources are limited. Family groups den in tree hollows, particularly in smooth-barked species (NSW NPWS 1999h). Home ranges vary between 0.65 and 8.55 hectares (NSW NPWS 1999h). This species nests in bowl-shaped, leaf lined nests in tree hollows. They live in family groups of a single adult male one or more adult females and offspring, and require abundant tree hollows for refuge and nest sites (DEC 2006aj). Births occur throughout the year, and can vary according to food availability (NSW NPWS 1999). Diet varies seasonally and consists of *Acacia* gum, eucalypt sap, nectar, honeydew and manna, with invertebrates and pollen providing protein.

The squirrel glider was recorded on six occasions during the Umwelt and HLA Envirosciences survey periods, being located within the Ironbark Woodland Complex and Forest Red Gum Riparian Woodland within the Proposed Disturbance Area, and Sheltered Grey Gum Woodland within the Proposed Offset Areas. Vegetation community mapping within the Study Area has identified a total of 1523 hectares of these vegetation communities within the Study Area. Of this, 938 hectares are located within the Proposed Disturbance Area, with the remaining 586 hectares located within the Proposed Offset Areas. On the basis of vegetation formations, this species was recorded from the Woodland and Riparian/Floodplain formations of the Proposed Disturbance Area, and the Woodland formation of the Proposed Offset Areas. The Study Area contains a total of 2209 hectares of these formations. Of this, 1304 hectares are located within the Proposed Disturbance Area, with the remaining 905 hectares being located within the Proposed Offset Areas. There is the potential that this species could occur within other vegetation communities and formations within the Study Area.

5.2.1.13 Brush-tailed rock-wallaby - *Petrogale penicillata*

Historically, the brush-tailed rock-wallaby (*Petrogale penicillata*) occurred from the Grampians in western Victoria to Nanago in south-eastern Queensland, roughly following the line of the Great Dividing Range (DEC 2005). The number of brush-tailed rock-wallabies has declined and the species' range has reduced and fragmented. The greatest declines have occurred in Victoria and in western and southern New South Wales, resulting in small isolated populations throughout the species' former range, particularly in the south (DEC 2005). In NSW they occur from the Queensland border in the north to the Shoalhaven in the south, with the population in the Warrumbungle Ranges being the western limit (DEC 2006ak). This species occupies rocky escarpments, outcrops and cliffs showing a preference for complex structures with fissures, caves and ledges facing north (DEC 2006ak). The habitat used by the brush-tailed rock-wallaby has been classified into three categories: (i) loose piles of large boulders containing a maze of subterranean holes and passage ways; (ii) cliffs (usually over 15 metres high) with many mid-level ledges and with some caves and/or ledges covered by overhangs; and (iii) isolated rock stacks, usually sheer-sided and often girded with fallen boulders (Short 1982). They forage mostly at night and feed predominantly on a wide variety of grasses, herbs and shrubs (DEC 2005). They browse on vegetation in and adjacent to rocky areas eating grasses and forbs as well as the foliage and fruits of shrubs and trees (DEC 2006ak). Rock-wallabies shelter or bask during the day in rock crevices, caves and overhangs and are most active at night. They are highly territorial and have strong site fidelity with an average home range size of about 15 hectares

(DEC 2006ak). They live in family groups of 2 – 5 adults and usually one or two juvenile and sub-adult individuals. Breeding is likely to be continuous, at least in the southern populations, with no apparent seasonal trends in births (DEC 2006ak).

The brush-tailed rock-wallaby was recorded from scats on four occasions during the Umwelt and HLA Envirosciences survey periods, being located within the Ironbark Woodland Complex and Tall Mixed Shrubland Complex within the Proposed Offset Areas. No brush-tailed rock-wallabies were observed during surveys. Vegetation community mapping within the Study Area has identified a total of 1445 hectares of these vegetation communities within the Study Area. Of this, 886 hectares are located within the Proposed Disturbance Area, with the remaining 559 hectares located within the Proposed Offset Areas. On the basis of vegetation formations, this species was recorded from the Woodland and Shrubland formation of the Proposed Offset Areas. The Study Area contains a total of 2252 hectares of these formations. Of this, 1251 hectares are located within the Proposed Disturbance Area, with the remaining 1001 hectares being located within the Proposed Offset Areas. There is the potential that this species could occur within other vegetation communities and formations within the Study Area.

The record of the brush-tailed rock-wallaby within the Proposed Offset Areas comes from the positive identification of a number of scats found in caves and overhangs on the Limb of Addy Hill escarpment. All of these scats were positioned in sheltered positions in crevices and overhangs where other wildlife were unable to trample or disturb them. No fresh scats were collected, despite repeat visits to identified sites. Despite the large amount of seasonal field survey (including target field survey for this species), no brush-tailed rock-wallabies were observed. No further indication of the presence of this species was recorded from the Study Area.

The record of this species from the Study Area is difficult to interpret. The scats found within the caves were desiccated, and it is not possible to determine how old they were. It is likely that scats would desiccate quickly on these dry, dusty caves, thus making it impossible to determine if these are relatively recent records, or are very old records from any number of years (or decades) ago. The main difficulty with this is that it is impossible to tell if these scats are from an extant population (of which no further evidence was obtained), or if the scats are from an extinct population of rock-wallabies.

Whether extant or not, the records of this species within the Study Area are likely to be related to known populations of this species within nearby Yengo, Wollemi and Goulburn River National Parks. These populations all fall within what is known as the Central Evolutionary Significant Unit (ESU) of this species (DEC 2005). Populations occurring within this ESU have been identified as being genetically distinct from those occurring within the Northern ESU and Southern ESU, respectively. Within the Central ESU, there is one listed endangered population, a number of populations facing marked declines, and a growing number of extinct populations (NSW Scientific Committee 2003a).

Of particular concern for this species is the increased isolation of the remaining small populations, leading to severe local declines and eventual extinctions (DEC 2005). While it is not possible to confirm this, it is highly likely that a small population of this species was once resident on the Limb of Addy Hill area, however this population has become extinct. It is likely that this occurred due to gradual habitat loss from vegetation clearing, genetic isolation, reduced dispersal/recruitment ability, predation and competition with introduced herbivores.

Due to the absence of records of live animals (despite a large survey effort, including target surveys for this species), it is considered unlikely that an extant population of this species is present within the Study Area.

5.2.1.14 Eastern freetail-bat - *Mormopterus norfolkensis*

This species has a distribution along the east coast of NSW from south of Sydney north into south-east Queensland, near Brisbane (Churchill 1998). Most records are from dry eucalypt forest and woodland east of the Great Dividing Range (DEC 2006al). This species has also been recorded over a rocky river in rainforest and wet sclerophyll forest (Churchill 1998). Generally only solitary animals are recorded (Allison & Hoye 2002). This species generally roosts in tree hollows, however have been recorded from roofs, under bark and the metal caps of telegraph poles (Churchill 1998). It generally forages above the forest canopy, over water and also on the ground.

The eastern freetail-bat (*Mormopterus norfolkensis*) was recorded on three occasions during the Umwelt and HLA Envirosciences survey periods, being located within the Slaty Box Woodland and Ironbark Woodland Complex within the Proposed Offset Areas. Vegetation community mapping within the Study Area has identified a total of 1921 hectares of these vegetation communities within the Study Area. Of this, 1131 hectares are located within the Proposed Disturbance Area, with the remaining 789 hectares located within the Proposed Offset Areas. On the basis of vegetation formations, this species was recorded from the Woodland formation of the Proposed Offset Areas. The Study Area contains a total of 2125 hectares of this formation. Of this, 1251 hectares are located within the Proposed Disturbance Area, with the remaining 874 hectares being located within the Proposed Offset Areas. There is the potential that this species could occur within other vegetation communities and formations within the Study Area.

5.2.1.15 Eastern bentwing-bat - *Miniopterus schreibersii oceanensis*

This species has an eastern distribution from Cape York along the coastal side of the Great Dividing Range, and into the southern tip of South Australia (Churchill 1998). Habitat varies widely, from rainforest, wet and dry sclerophyll forest, monsoon forest, open woodland, paperbark forests and open grasslands (Churchill 1998). It is generally a cave-dwelling species, congregating in maternity caves with very specific temperature and humidity ranges (DEC 2006am). During the non-breeding season, this species will disperse to satellite caves, generally within 300 kilometres (Churchill 1998). Breeding or roosting colonies can number from 100 to 150,000 individuals (DEC 2006am). The eastern bentwing-bat (*Miniopterus schreibersii oceanensis*) hibernates over winter in the southern parts of its range (Churchill 1998). It has been recorded roosting in a variety of man-made structures including buildings and culverts (Dwyer 2002b), as well as derelict mines and storm-water tunnels. A single young is born in December (Churchill 1998). The species hunts in forested areas, catching moths and other flying insects above the tree tops.

The eastern bentwing-bat was recorded on 12 occasions during the Umwelt and HLA Envirosciences survey periods, located within the Slaty Box Woodland, Ironbark Woodland Complex and Bulloak Woodland within the Proposed Disturbance Area, and Slaty Box Woodland, Ironbark Woodland Complex and Sheltered Grey Gum Woodland within the Proposed Offset Areas. Vegetation community mapping within the Study Area has identified a total of 2099 hectares of these vegetation communities within the Study Area. Of this, 1231 hectares are located within the Proposed Disturbance Area, with the remaining 868 hectares located within the Proposed Offset Areas. On the basis of vegetation formations, this species was recorded from the Woodland formation of the Proposed Disturbance Area, and the Woodland formation of the Proposed Offset Areas. The Study Area contains a total of 2125 hectares of this formation. Of this, 1251 hectares are located within the Proposed Disturbance Area, with the remaining 874 hectares being located within the Proposed Offset Areas. There is the potential that this species could occur within other vegetation communities and formations within the Study Area.

5.2.1.16 Eastern false pipistrelle - *Falsistrellus tasmaniensis*

This species has a range from south-eastern Queensland, through NSW and Victoria and into Tasmania (Churchill 1998). Habitat includes sclerophyll forest from the Great Dividing Range to the coast. This species prefers moist habitats, with trees taller than 20 metres (DEC 2006an). It generally roosts in tree hollows in groups of 6 – 36, but is occasionally recorded from caves or buildings (Churchill 1998). This species hunts beetles, moths, weevils and other flying insects above or just below the tree canopy. The eastern false pipistrelle (*Falsistrellus tasmaniensis*) appears to hibernate over winter in southern parts (Phillips 1995). A single young is born in December (Churchill 1998).

The eastern false pipistrelle was recorded on two occasions during the Umwelt and HLA Envirosciences survey periods, being located within the Coast Myall Exposed Woodland and Ironbark Woodland Complex within the Proposed Offset Areas. Vegetation community mapping within the Study Area has identified a total of 1468 hectares of these vegetation communities within the Study Area. Of this, 886 hectares are located within the Proposed Disturbance Area, with the remaining 581 hectares located within the Proposed Offset Areas. On the basis of vegetation formations, this species was recorded from the Shrubland and Woodland formations of the Proposed Offset Areas. The Study Area contains a total of 2252 hectares of these formations. Of this, 1251 hectares are located within the Proposed Disturbance Area, with the remaining 1001 hectares being located within the Proposed Offset Areas. There is the potential that this species could occur within other vegetation communities and formations within the Study Area.

5.2.1.17 Large-eared pied bat - *Chalinolobus dwyeri*

The large-eared pied bat (*Chalinolobus dwyeri*) is found mainly in areas with extensive cliffs and caves, from Rockhampton in Queensland south to Bungonia in the NSW Southern Highlands (DEC 2006ao). It is generally rare with a very patchy distribution in NSW. There are scattered records from the New England Tablelands and North West Slopes (DEC 2006ao). It has been recorded frequenting low to mid-elevation dry open forest and woodland close roosting habitat (DEC 2006ao). Found in well-timbered areas containing gullies. It is likely to tolerate a wide range of habitats (Hoye & Dwyer 2002). This species tends to roost in the twilight zones of mines and caves, generally in colonies or common groups (Churchill 1998). This species is likely to hibernate through the coolest months (DEC 2006ao). Females have been recorded raising young in maternity roosts (c. 20-40 females) from November through to January in roof domes in sandstone caves. They remain loyal to the same cave over many years (DEC 2006ao). Females give birth (generally to twins) in November (Churchill 1998). The relatively short, broad wing combined with the low weight per unit area of wing indicates manoeuvrable flight. This species probably forages for small, flying insects below the forest canopy.

The large-eared pied bat was recorded on three occasions during the Umwelt and HLA Envirosciences survey periods, being located within the Slaty Box Woodland and Tall Mixed Shrubland Complex within the Proposed Offset Areas. Vegetation community mapping within the Study Area has identified a total of 579 hectares of these vegetation communities within the Study Area. Of this, 245 hectares are located within the Proposed Disturbance Area, with the remaining 334 hectares located within the Proposed Offset Areas. On the basis of vegetation formations, this species was recorded from the Woodland and Shrubland formations of the Proposed Offset Areas. The Study Area contains a total of 2252 hectares of these formations. Of this, 1251 hectares are located within the Proposed Disturbance Area, with the remaining 1001 hectares being located within the Proposed Offset Areas. There is the potential that this species could occur within other vegetation communities and formations within the Study Area.

5.2.1.18 Large-footed myotis - *Myotis adversus*

This is a coastal species, ranging from the Kimberley to South Australia (Churchill 1998). It is rarely found more than 100 kilometres inland, except along major rivers (DEC 2006ap). It will occur in most habitat types providing they are near to water (Richards 1995). It will forage over streams and pools, catching insects and small fish by raking their feet across the water surface (DEC 2006ap). This species is commonly cave-dwelling in groups of 10 to 15, however it is also recorded from tree hollows, dense vegetation, bridges, mines and drains (Churchill 1998). When breeding, it roosts in small groups, with males defending a territory and a harem of females (Richards 1995). A single young is born in November through to December (Churchill 1998).

The large-footed myotis (*Myotis adversus*) was recorded on three occasions during the Umwelt and HLA Envirosciences survey periods, being located at two dams within the Ironbark Woodland Complex from the Proposed Disturbance Area, and at one dam within the Ironbark Woodland Complex from the Proposed Offset Areas. There are approximately 44 dams recorded in the Study Area, 17 in the Proposed Disturbance Area, and 27 in the Proposed Offset Areas. Vegetation community mapping within the Study Area has identified a total of 1393 hectares of this vegetation community within the Study Area. Of this, 886 hectares are located within the Proposed Disturbance Area, with the remaining 507 hectares located within the Proposed Offset Areas. On the basis of vegetation formations, this species was recorded from the Woodland formation of the Proposed Disturbance Area, and the Woodland formation of the Proposed Offset Areas. The Study Area contains a total of 2125 hectares of this formation. Of this, 1251 hectares are located within the Proposed Disturbance Area, with the remaining 874 hectares being located within the Proposed Offset Areas. There is the potential that this species could occur within other vegetation communities and formations within the Study Area.

5.2.1.19 Greater broad-nosed bat - *Scoteanax rueppellii*

The greater broad-nosed bat (*Scoteanax rueppellii*) is found mainly in the gullies and river systems that drain the Great Dividing Range, from north-eastern Victoria to the Atherton Tableland. It extends to the coast over much of its range. In NSW it is widespread on the New England Tablelands, however does not occur at altitudes above 500 metres (DEC 2006aq). This species occurs in moist gullies and river systems draining the Great Dividing Range, as well as a variety of woodland, forest and rainforest habitats (Hoye & Richards 2002). It has been recorded roosting in hollow tree trunks and branches, as well as old buildings (Churchill 1998). This species forages after sunset, flying slowly and directly along creek and river corridors at an altitude of 3 - 6 metres. Open woodland habitat and dry open forest suits the direct flight of this species as it searches for beetles and other large, slow-flying insects; this species has been known to eat other bat species (DEC 2006aq). Little is known of the reproductive cycle of the species, however, females congregate at maternity sites, located in suitable trees, where they appear to exclude males for the birth and raising of the single young in January (Hoye & Richards 2002).

The greater broad-nosed bat was recorded on one occasion during the Umwelt and HLA Envirosciences survey periods, being located within the Bulloak Woodland within the Proposed Disturbance Area. Vegetation community mapping within the Study Area has identified a total of 100 hectares of this vegetation community within the Study Area. Of this, 100 hectares are located within the Proposed Disturbance Area, with less than one hectare falling within the Proposed Offset Areas. On the basis of vegetation formations, this species was recorded from the Woodland formation of the Proposed Disturbance Area. The Study Area contains a total of 2125 hectares of these formations. Of this, 1251 hectares are located within the Proposed Disturbance Area, with the remaining 874 hectares being located within the Proposed Offset Areas. There is the potential that this species could occur within other vegetation communities and formations within the Study Area.

5.2.1.20 Eastern cave bat - *Vespadelus troughtoni*

This species has been recorded in a broad band along eastern Australia on both sides of the Great Dividing Range, from Cape York to Kempsey (Churchill 1998). There are additional records of this species from the New England Tablelands and the upper north coast of NSW. The western limit appears to be the Warrumbungle Range, and there is a single record from southern NSW, east of the ACT (DEC 2006as). This cave roosting species is known from drier forests and tropical woodlands from the coastal zone and Great Dividing Range to the semi-arid zone (Parnaby 2002). It is usually found in dry open forest and woodland, near cliffs or rocky overhangs; has been recorded roosting in disused mine workings, occasionally in colonies of up to 500 individuals (DEC 2006as). It is occasionally recorded roosting in buildings (Parnaby 2002). Occasionally found along cliff-lines in wet eucalypt forest and rainforest. Roost sites are frequently in well-lit areas. Little further is known about their biology. Little is understood of its feeding or breeding requirements or behaviour (DEC 2006as).

The eastern cave bat (*Vespadelus troughtoni*) was recorded on 10 occasions during the Umwelt and HLA Envirosciences survey periods, being located within the Ironbark Woodland Complex, Forest Red Gum Riparian Woodland and Bulloak Woodland within the Proposed Disturbance Area, and Ironbark Woodland Complex and Slaty Box Woodland within the Proposed Offset Areas. Vegetation community mapping within the Study Area has identified a total of 2072 hectares of these vegetation communities within the Study Area. Of this, 1282 hectares are located within the Proposed Disturbance Area, with the remaining 790 hectares located within the Proposed Offset Areas. On the basis of vegetation formations, this species was recorded from the Woodland and Riparian/Floodplain formations of the Proposed Disturbance Area, and the Woodland formation of the Proposed Offset Areas. The Study Area contains a total of 2209 hectares of these formations. Of this, 1304 hectares are located within the Proposed Disturbance Area, with the remaining 905 hectares being located within the Proposed Offset Areas. There is the potential that this species could occur within other vegetation communities and formations within the Study Area.

5.2.1.21 Rainbow bee-eater - *Merops ornatus*

The rainbow bee-eater (*Merops ornatus*) is a common migrant in woodland and timbered plains throughout Australia during September and April, with a resident population in northern Australia. The species is usually found in small groups, however it sometimes roost in hundreds in small leafy trees. Nesting occurs in long tunnels in sand banks or sloping sandy soil (Slater et al. 2003).

The rainbow bee-eater was recorded on 14 occasions during the Umwelt and HLA Envirosciences survey periods, being located within the Forest Red Gum Riparian Woodland, Slaty Box Woodland and Ironbark Woodland Complex of the Proposed Disturbance Area, and Swamp Oak Riparian Forest and Ironbark Woodland Complex within the Proposed Offset Areas. Vegetation community mapping within the Study Area has identified a total of 1993 hectares of these vegetation communities within the Study Area. Of this, 1184 hectares are located within the Proposed Disturbance Area, with the remaining 809 hectares located within the Proposed Offset Areas. On the basis of vegetation formations, this species was recorded from the Riparian/Floodplain and Woodland formations of the Proposed Disturbance Area, and the Riparian/Floodplain and Woodland formations of the Proposed Offset Areas. The Study Area contains a total of 2209 hectares of these formations. Of this, 1304 hectares are located within the Proposed Disturbance Area, with the remaining 905 hectares being located within the Proposed Offset Areas. There is the potential that this species could occur within other vegetation communities and formations within the Study Area.

5.2.1.22 White-bellied sea-eagle - *Haliaeetus leucogaster*

The white-bellied sea-eagle (*Haliaeetus leucogaster*) is a common resident or nomad along the coast and on rivers, lakes and dams. Nesting occurs in a large pile of sticks in a large tree, or on the ground if on an island (Slater et al. 2003).

The white-bellied sea-eagle was recorded on one occasion during the Umwelt and HLA Envirosciences survey periods, being located within the Slaty Box Woodland within the Proposed Disturbance Area. Vegetation community mapping within the Study Area has identified a total of 527 hectares of this vegetation community within the Study Area. Of this, 245 hectares are located within the Proposed Disturbance Area, with the remaining 282 hectares located within the Proposed Offset Areas. On the basis of vegetation formations, this species was recorded from the Woodland formation of the Proposed Disturbance Area. The Study Area contains a total of 2125 hectares of this formation. Of this, 1251 hectares are located within the Proposed Disturbance Area, with the remaining 874 hectares being located within the Proposed Offset Areas. There is the potential that this species could occur within other vegetation communities and formations within the Study Area.

5.2.1.23 White-throated needletail - *Hirundapus caudacutus*

The white-throated needletail (*Hirundapus caudacutus*) is a common migrant from October to April, mainly in eastern Australia and Tasmania, with scattered records occurring elsewhere (Slater et al. 2003). It is usually observed in the air, over most habitat types except desert, but is most often observed over hillsides (Flegg 2002). The species is attracted to low-pressure weather along the east coast, and usually arrives ahead of storms in large flocks, mostly over or east of the Great Dividing Range (Slater et al. 2003).

The white-throated needletail was recorded on one occasion during the Umwelt and HLA Envirosciences survey periods, being located above the Ironbark Woodland Complex of the Proposed Offset Areas. Vegetation community mapping within the Study Area has identified a total of 1393 hectares of this vegetation community within the Study Area. Of this, 886 hectares are located within the Proposed Disturbance Area, with the remaining 507 hectares located within the Proposed Offset Areas. On the basis of vegetation formations, this species was recorded from the Woodland formation of the Proposed Offset Areas. The Study Area contains a total of 2125 hectares of this formation. Of this, 1251 hectares are located within the Proposed Disturbance Area, with the remaining 874 hectares being located within the Proposed Offset Areas. There is the potential that this species could occur within other vegetation communities and formations within the Study Area.

5.2.1.24 Satin flycatcher - *Myiagra cyanoleuca*

The satin flycatcher (*Myiagra cyanoleuca*) is an uncommon migrant between south-east Australia and New Guinea between September and March (Slater et al. 2003), in dense forest, woodland and scrub, and occasionally swampy woodland and mangroves (Flegg 2002). Nesting occurs in a neat cup of bark, grass and cobwebs (Slater et al. 2003).

The satin flycatcher was recorded on one occasion during the Umwelt and HLA Envirosciences survey periods, being located within the Ironbark Woodland Complex of the Proposed Disturbance Area. Vegetation community mapping within the Study Area has identified a total of 1393 hectares of this vegetation community within the Study Area. Of this, 886 hectares are located within the Proposed Disturbance Area, with the remaining 507 hectares located within the Proposed Offset Areas. On the basis of vegetation formations, this species was recorded from the Woodland formation of the Proposed Disturbance Area. The Study Area contains a total of 2125 hectares of this formation. Of this, 1251 hectares are located within the Proposed Disturbance Area, with the remaining 874 hectares being located within the Proposed Offset Areas. There is the potential that this species could occur within other vegetation communities and formations within the Study Area.

5.3 Threatened Fauna Species with no Potential Habitat

A number of threatened fauna species are known to occur in the vicinity of the Study Area. Several of these species are considered unlikely to occur in the Study Area, as potential habitat for these species is either absent or very limited. Each of these species is identified below, and a justification is provided for their exclusion from further consideration in this assessment.

Giant barred frog (*Mixophyes iteratus*) – this species has a distribution from the coast and ranges from south-east Queensland to the Hawkesbury River in New South Wales. A particular stronghold occurs in north-eastern New South Wales, in the Coffs Harbour/Dorrigo area.

Giant barred frogs require deep, damp leaf litter in rainforests, moist eucalypt forests and adjacent dry eucalypt forests. This species usually occurs at elevations below 1000 metres. The Study Area does not contain suitable habitat for this species.

There is only one record of this species on the Muswellbrook 1:100,000 Map Sheet, with this record from Goulburn River National Park, near Wilpinjong, to the south-west of the Study Area.

Despite extensive seasonal surveys, this species was not recorded within the Study Area, and it is considered unlikely that potential habitat exists for this species within the Study Area, or in the immediate locality.

Freckled duck (*Stictonetta naevosa*) – this species has a distribution across south-eastern and south-western Australia, and occurs as a vagrant elsewhere. It is particularly dependent on large, temporary swamps and wetlands created by flooding of the Bulloo, Lake Eyre and Murray-Darling River systems. This species will disperse large distances during major inland droughts, and can be found in coastal area of New South Wales and Victoria in such times.

Preferred swamps and wetlands generally contain high levels of cumbungi, lignum or tea trees. They have been known to utilise permanent waters such as lakes, reservoirs, dams and sewage ponds in times of drought.

The nearest record of this species is from Lake Liddell, about 30 kilometres to the south-east of the Study Area.

Despite extensive seasonal surveys, this species was not recorded within the Study Area, and it is considered unlikely that potential habitat exists for this species within the Study Area, or in the immediate locality.

Malleefowl (*Leipoa ocellata*) – this species is recorded generally from the southern half of western New South Wales, from the Pilliga forest, south-west to the Griffith and Wentworth districts, excluding the southern Riverina. Disjunct records occur at "Wallanburra" Station, 45 kilometres south-west of Bourke in Mulga/Bimble Box during 1991, Gongolgon in 1994, and Goulburn River National Park in 1989, however the current status of these populations is unknown. Habitat for this species generally consists of mallee communities, preferring the tall, dense and floristically-rich mallee found in higher rainfall (300-450 mm mean annual rainfall) areas. Malleefowl are less frequently found in other eucalypt woodlands (e.g. mixed western grey box and yellow gum (*Eucalyptus leucoxylon*) or bimble box (*Eucalyptus populnea*), ironbark-callitris pine, callitris pine, mulga (*Acacia aneura*), and gidgee (*Acacia* *cambagei*)). Preferred soils include light sandy to sandy loam soils and habitats with a dense but discontinuous canopy, dense and variable shrub and herb layers.

There are no records of this species from the Muswellbrook 1:100,000 Map Sheet. While this species was previously recorded from Goulburn River National Park (to the south-west of the Study Area), recent surveys have failed to confirm the status of the species in this area (NSW NPWS 2001c).

Despite extensive seasonal surveys, this species was not recorded within the Study Area, and it is considered unlikely that potential habitat exists for this species within the Study Area, or in the immediate locality.

Common greenshank (*Tringa nebularia*) – this species has a widespread distribution across Australia, being more common in coastal areas, than the inland.

Common greenshanks frequent coastal lagoons, sheltered estuaries and bays, freshwater marshes, dams and sewage ponds.

There are no records of this species from the Muswellbrook 1:100,000 Map Sheet. The nearest record of this species is from sewage treatment works at Maitland, approximately 90 kilometres to the south-east of the Study Area.

Despite extensive seasonal surveys, this species was not recorded within the Study Area, and it is considered unlikely that potential habitat exists for this species within the Study Area, or in the immediate locality.

Japanese snipe (*Gallinago hardwickii*) – this species has a widespread distribution along the east and south-east coast of Australia. This species generally frequents muddy freshwater shallows, such as wetlands, dams and sewage ponds.

There are no records of this species from the Muswellbrook 1:100,000 Map Sheet. The nearest record of this species is from Barrington Tops Nations Park, approximately 70 kilometres to the east of the Study Area.

Despite extensive seasonal surveys, this species was not recorded within the Study Area, and it is considered unlikely that potential habitat exists for this species within the Study Area, or in the immediate locality.

Australian painted snipe (*Rostratula benghalensis australis*)/Painted snipe (*Rostratula benghalensis s. lat.*) – The Australian painted snipe has also been referred to as the painted snipe or greater painted snipe, *Rostratula benghalensis* or *Rostralula benghalensis australis*, as it was previously considered to be part of the greater painted snipe species that occurs also in Africa and Asia. Recent research indicates that the Australian painted snipe is a separate species. This taxonomic history is reflected in the names that have been used to list the species under State and Territory threatened species legislation, under the China-Australia Migratory Bird Agreement (CAMBA) and under the migratory provisions of the EPBC Act 1999. While the DEH Protected Matters Database makes reference to the painted snipe (*Rostratula benghalensis s. lat.*), this will be treated as the Australian painted snipe (*Rostratula benghalensis australis*).

The Australian painted snipe has been recorded throughout Australia, however the majority of occurrences and breeding records are from the south-east mainland. Records for this species in New South Wales range from the Paroo wetlands, Lake Cowell, Macquarie Marshes and Hexham Swamp, however this species is most common in the Murray-Darling Basin. This species appears to prefer fringes of swamps, dams and nearby marshy areas where there is a cover of grasses, lignum, low scrub or open timber.

There are no records of this species from the Muswellbrook 1:100,000 Map Sheet. The nearest record of this species is from Maitland, approximately 90 kilometres to the south-east of the Study Area.

Despite extensive seasonal surveys, this species was not recorded within the Study Area, and it is considered unlikely that potential habitat exists for this species within the Study Area, or in the immediate locality.

5.4 Likelihood for Endangered Fauna Populations

No endangered fauna populations as listed under the TSC Act or EPBC Act were recorded within the Study Area.

The DEC Atlas of NSW Wildlife (March 2006) (DEC 2006a) lists a number of endangered fauna populations (as listed on Part 2 of Schedule 1 of the TSC Act 1995) that are known, or may potentially occur within, the Muswellbrook 1:100,000 Map Sheet. These have been listed below, with a response on the likelihood of the endangered population occurring within, or near to, the Study Area.

Emu (*Dromaius novaehollandiae*) population in the NSW North Coast Bioregion and Port Stephens LGA

The emu (*Dromaius novaehollandiae*) has a broad, but patchy distribution throughout New South Wales and elsewhere in Australia. It occupies a range of predominantly open habitats, including plains, grasslands, woodlands and shrubs, and may occur occasionally in forest (NSW Scientific Committee 2002a).

An isolated population of emus occurs in the NSW North Coast Bioregion and Port Stephens LGA. The population is disjunct from other populations in the Sydney Basin and New England Tableland Bioregion. The population of emus in the NSW North Coast Bioregion and Port Stephens LGA represents the north-eastern limit of the species in NSW. The majority of recent records are concentrated between Coffs Harbour and Ballina, with occasional records inland of the coastal ranges (NSW Scientific Committee 2002a).

This species was not recorded within the Study Area, despite considerable seasonal survey effort. There are no records of this species within the Muswellbrook 1:100,000 Map Sheet. It is considered that such a large, readily-identifiable bird would have been recorded during surveys, if a population was present within, or near to the Study Area.

The Study Area does not fall within the geographic definition of the endangered population. It is not considered that examples of this endangered population occur in, or near to the Study Area. The proposed development will not result in an impact on the endangered population of emu in the NSW North Coast Bioregion and Port Stephens LGA.

Broad-toothed Rat population at Barrington Tops in the Gloucester, Scone and Dungog LGAs

In New South Wales the broad-toothed rat (*Mastacomys fuscus*) is known from five disjunct populations, the largest being in Kosciuszko National Park. The population identified in Barrington Tops is of significant conservation value as it is the second largest known population in New South Wales (NSW Scientific Committee 2001i). This species is uncommon, and is generally found in alpine and sub-alpine heathlands and open eucalypt woodlands in areas that are characterised by high rainfall, a cool summer, and a cool to cold winter (NSW Scientific Committee 2001i).

The species appears to be restricted to patches where there is a dense ground cover of grasses, sedges and shrubs. In winter habitats may be covered by snow, but the animals frequent the space below the shrubs and grass tussocks (NSW Scientific Committee 2001i).

This species was not recorded within the Study Area, despite considerable seasonal survey effort. There are no records of this species within the Muswellbrook 1:100,000 Map Sheet. The extensive trapping and hair tube surveys completed should have produced a record of this species, if a population was present within the Study Area.

The Study Area does not fall within the geographic definition of the endangered population. The proposed development will not result in an impact on the endangered population of broad-toothed rat at Barrington Tops in the Gloucester, Scone and Dungog LGAs.

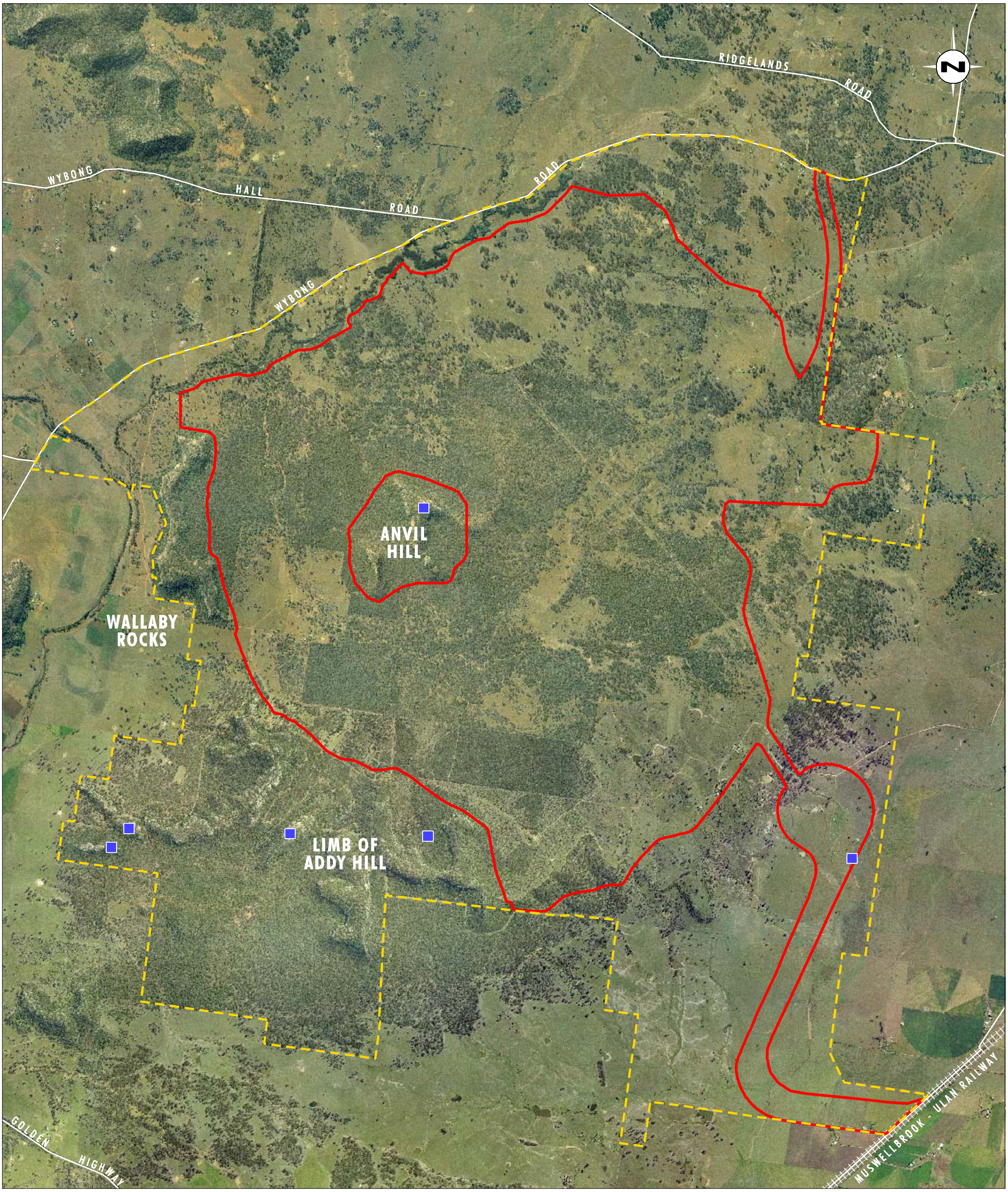
Australian Brush-turkey (*Alectura lathami*) in the Nandewar and Brigalow Belt South Bioregions

The distribution of the Australian brush-turkey (*Alectura lathami*) is mainly coastal, running from Cape York south to the Illawarra in NSW (NSW Scientific Committee 2005b), where it occurs in forested and wooded areas of tropical and warm-temperate districts, particularly above 300 metres to at least 1200 metres altitude. The species is commonly associated with closed forest, including rainforest and vine thickets, as well as dense woodland habitats. More open dry woodland habitats are also used including open woodland dominated by spotted gum (*Corymbia maculata)*, brigalow (*Acacia harpophylla)*, and belah (*Casuarina cristata)* (NSW Scientific Committee 2005b). In inland NSW, this species will use the dry rainforest community within the Semi-evergreen Vine Thicket in the Brigalow Belt South and Nandewar Bioregions Endangered Ecological Community (NSW Scientific Committee 2005b).

A population of the Australian brush-turkey is known from the Nandewar and Brigalow Belt South Bioregions. Recent records for the species show the population to range from north-east of Warialda, to Narrabri, approximately 115 kilometres to the south-west, and occur within the local government areas of Yallaroi, Bingara, Narrabri, Barraba and Moree Plains (NSW Scientific Committee 2005b). The majority of records are from Mount Kaputar National Park and nearby Deriah State Forest, with a smaller cluster of records from Warialda State Forest. An outlying 2003 record is also known from just north of Severn State Forest, approximately 75 kilometres north-east of Warialda, in the Inverell Local Government Area. It is thought that a western expansion in the range of the Australian brush-turkey followed the spread in the early 1900s of the exotic weed prickly pear (*Opuntia stricta*), which the species used for food and mound construction (NSW Scientific Committee 2005b). Currently, records nearest this population are north of the Queensland-NSW border, approximately 40 kilometres to the north-east. There are no records between the population and the eastern escarpment, a distance of at least 120 kilometres. The population of the Australian brush-turkey in the Nandewar and Brigalow Belt South Bioregions is therefore both disjunct and at the western limit of the species' range in NSW (NSW Scientific Committee 2005b).

This species was not recorded within the Study Area, despite considerable seasonal survey effort. There are no records of this species within the Muswellbrook 1:100,000 Map Sheet. It is considered that such a large, readily-identifiable bird would have been recorded during surveys, if a population was present within, or near to the Study Area.

The Study Area does not fall within the geographic definition of the endangered population. The proposed development will not result in an impact on the endangered population of Australian brush-turkey in the Nandewar and Brigalow Belt South Bioregions.



Base Map: Dept. of Lands (2003), ortho-rectified by Plateau Images

Legend

- Proposed Disturbance Area
- Study Area
- Potential Koala Habitat

FIGURE 5.2

SEPP 44 Koala Habitat Assessment Results

5.5 SEPP 44 (Koala Habitat) Assessment Results

A total of 158 sites were assessed for the presence and percentage composition of SEPP 44 Schedule 2 tree species (**Figure 3.4**). Six of these sites were identified as potential koala (*Phascolarctos cinereus*) habitat, as the upper and lower strata consisted of 15 per cent or more of Schedule 2 tree species (**Figure 5.2**). Of these potential habitat sites, only one occurred within the Proposed Disturbance Area.

The identification of potential koala habitat within the Study Area required further investigation into the likelihood of koala core habitat. No koalas were identified during walking (23 hours) or driving (19 hours) spotlight searches. No koalas responded to call playback sessions (20 diurnal and 9 nocturnal). No koala scats were collected during the searches of 493 trees across the 55 treed condition assessment survey sites. No koalas were sighted during 75 kilometres of visual canopy searches.

No koalas or koala scats were identified in any part of the Proposed Disturbance Area despite a significant level of survey effort. Therefore no koala core habitat was identified in the Proposed Disturbance Area. As a result, the Proposed Disturbance Area is not considered to provide koala habitat.

During opportunistic searching of the ground while undertaking other ecological survey activities, a small number of koala scats were collected from underneath a single tree in the Proposed Offset Areas (**Figure 5.1**). The scats were positively identified by Barbara Triggs, a recognised expert in the field. The failure to find individual koalas or further koala scats within the Study Area (despite high levels of survey effort), suggests that Proposed Offset Areas is of very marginal habitat quality for the koala and is most likely only used by dispersing individuals or sub-dominant animals at very low density. Therefore the Proposed Offset Areas is considered not to provide core koala habitat.

The DEC Atlas of NSW Wildlife (Feb 2006 search) lists eight koala records within a 20 kilometre radius of the centre of the Study Area. None of the database records occur within the Study Area or immediate surrounds. No other confirmed historic records are known in the Study Area. Anecdotal evidence from one landholder in the Proposed Disturbance Area near Wallaby Rocks indicates that koalas were last known to occur in that area in the early 1950s.

As a result of the above assessment, SEPP 44 does not place any constraints on the Project.

6.0 Condition Assessment Results

6.1 Vegetation Formations of the Study Area

As part of the condition assessment process, vegetation communities were grouped into broad vegetation formations (see **Section 3.4**), which are structurally-based classifications of vegetation. Four formations were recognised (Woodland, Riparian/Floodplain, Shrubland and Grassland), all of which are present in the Proposed Disturbance Area and Proposed Offset Areas, although the representation of Shrubland within the Proposed Disturbance Area covers only 0.3 hectares.

The Proposed Disturbance Area is 2238 hectares in size and includes three broad vegetation formations: Woodland, Riparian/Floodplain and Grassland, as well as a very small representation of the Shrubland vegetation formation (**Table 6.1**). The Woodland and Grassland vegetation formations will be subjected to the largest amounts of clearing for the Project.

Table 6.1 – Area of Vegetation Formations within Proposed Disturbance Area and Proposed Offset Areas

	Area (ha)	
Vegetation Formation	**Proposed Disturbance Area**	**Proposed Offset Areas**
Woodland	1251	874
Riparian/Floodplain	53	31
Shrubland	0.3	127
Grassland	934	872
Total	**2238**	**1904**

The Proposed Offset Areas occupies 1904 hectares, and consists of all four vegetation formations: Woodland, Riparian/Floodplain, Shrubland and Grassland.

Larger areas of Woodland, Grassland and Riparian/Floodplain formations occur in the Proposed Disturbance Area than the Proposed Offset Areas, while the majority of the Shrubland formation occurs in the Proposed Offset Areas.

6.2 Fauna Habitat Value of Study Area

A detailed methodology was designed to allow the direct comparison between the fauna habitat value of the Proposed Disturbance Area and the Proposed Offset Areas (see **Section 3.6.2**). The data collected related primarily to fauna habitat, in particular key habitat necessary for the threatened fauna species that were known or expected to occur in the Study Area.

This section describes the results of the condition assessment, including a summary of the characteristics of the vegetation formations and habitat value for both the Proposed Disturbance Area and Proposed Offset Areas.

A total of 85 sampling sites were completed during condition assessment field sampling (**Table 6.2**). The final number of sites per vegetation formation varied from the planned number of sites allocated to each vegetation formation (according to its total area, see **Section 3.6.2.1**) as a result of modifications to vegetation formation boundaries due to ground truthing, and the modification of the Proposed Disturbance Area boundary following the completion of field sampling. The very small area of Shrubland within the Proposed Disturbance Area prevented sampling within this formation, thus it was not included within the condition assessment results.

Table 6.2 - Number of Sites completed per Vegetation Formation

	Number of Sites Sampled	
Vegetation Formation	**Proposed Disturbance Area**	**Proposed Offset Areas**
Woodland	16	14
Riparian/Floodplain	8	5
Shrubland	N/A	12
Grassland	18	12
Total	**42**	**43**

6.2.1 Woodland Formation

A summary of the vegetation features and habitat values of the Woodland formation of the Study Area is shown in **Table 6.3**.

Table 6.3 – Summary of Condition Assessment Results for Woodland Formation

	Proposed Disturbance Area	Proposed Offset Areas
Total Area	1251 hectares	874 hectares
Structure	Woodland, usually comprising trees (12 m, 20% cover), mid-understorey (5 m, 20% cover), shrubs (1.5 m, 15% cover) and groundcovers (0.3 m, 30-70% cover)	Woodland, usually comprising trees (13 m, 20-30% cover), mid-understorey (5 m, 20% cover), shrubs (1-2 m, 25% cover) and groundcovers (0.2 m, 30-40% cover)
Average Canopy Cover %	20 %	23%
Age/maturity	Range of age classes comprising regeneration, middle aged and mature	Middle-aged and regeneration dominant age classes with some areas of mature and old growth trees
Dominant Species	*Eucalyptus crebra, Eucalyptus dawsonii, Eucalyptus moluccana, Notelaea microcarpa* var. *microcarpa, Allocasuarina luehmannii, Dodonaea viscosa, Aristida ramosa, Austrostipa scabra*	*Eucalyptus crebra, Eucalyptus dawsonii, Callitris endlicheri, Notelaea microcarpa* var. *microcarpa, Allocasuarina luehmannii, Canthium odoratum, Dodonaea viscosa, Spartothamnella juncea, Hibbertia obtusifolia, Aristida ramosa*
Average DBH	169 millimetres	182 millimetres
Vegetation Health	Good, some instances of mild to moderate dieback and mistletoe infestation	Good, some areas of mild dieback and moderate mistletoe infestation

Table 6.3 – Summary of Condition Assessment Results for Woodland Formation (cont)

	Proposed Disturbance Area	Proposed Offset Areas
Disturbance	Mild, slight to moderate levels of grazing, rare signs of fire, some sites with slight sheet erosion and all sites with mild weed infestation	Mild, highly scattered areas of recent fire, slight levels of grazing, some sites with slight sheet erosion and all sites with mild weed infestation
Hollow-bearing Tree Average Density per hectare	1.6	7.1

6.2.1.1 Condition of Proposed Disturbance Area

The Woodland formation of the Proposed Disturbance Area is dominated by Ironbark Woodland Complex, which is a highly variable vegetation community. It has moderate structural complexity, however it mostly comprises regrowth vegetation that is probably between 40 and 70 years old. In general, the vegetation is in good health, and supports a high diversity of native plant species.

This vegetation formation exhibited mild disturbance, with slight to moderate levels of grazing evident (predominantly macropods) and some scattered signs of fire. Some areas of slight sheet erosion were present, while all areas contained a mild coverage of weed species.

Old growth trees were extremely rare in this formation, with most areas featuring a range of age classes comprising combinations of regeneration, middle aged and mature trees. The average DBH of trees in this formation was 169 mm. The Woodland formation exhibited an average of 1.6 hollow-bearing trees per hectare, and there were also scattered large stags.

All four general layers of habitat, ground cover, understorey, mid-understorey and canopy were usually present across the Woodland formation of the Proposed Disturbance Area. The canopy was typically 12 metres in height with a density of 20% cover and typically comprised two main tree species, narrow-leaved ironbark (*Eucalyptus crebra*) and slaty box (*Eucalyptus dawsonii*). Mild levels of dieback and mistletoe were present in the canopy.

Canopies on average contained a few bayonet branches and a few to moderate number of bare branches for bird perching sites. Hollow-bearing trees averaged a density of 1.6 trees per hectare. The distribution of individual tree hollow size classes per hectare averaged 3.1 small hollows (26-50 mm), 1.6 medium hollows (51-100 mm), 3.1 large hollows (101-300 mm) and no very small (<25 mm) or very large hollows (>301 mm).

The mid-understorey layer of this formation typically reached five metres in height with a density of 23% cover of low trees and saplings. The understorey averaged 16% cover and typically contained three species reaching an average 1.5 metres in height. The ground cover averaged 40% cover comprised of an average 23 species typically reaching 0.3 metres in height. Within the ground layer, 80% of logs were solid with no bark and averaged a density of 328 logs per hectare. Stumps recorded within this formation were generally solid without bark, and averaged a density of 75 stumps per hectare. Only small areas of rock cover were recorded in this formation (6% of ground cover).

All general woodland fauna habitat types were present within this formation. The canopy provided perching, roosting and foraging habitat for canopy species, as well as nesting or denning habitat for all but the smallest and largest of hollow-dependent species. The mid-understorey and understorey layers provide habitat for the various bird and bat species that forage, perch, nest or roost below the canopy and above the ground layer. The ground layer provided habitat for species requiring either low vegetation or litter cover. Only small areas of rock cover were recorded, providing only small areas of habitat for reptiles. Log and stump cover provided habitat small mammal and reptile and amphibian species.

6.2.1.2 Condition of Proposed Offset Areas

The Woodland formation of the Proposed Offset Areas is dominated by Ironbark Woodland Complex, which is a highly variable vegetation community. It has reasonable levels of structural complexity, and includes significant areas of regrowth vegetation that is probably between 40 and 70 years old as well as large areas of potentially old growth vegetation. In general, the vegetation is in good health, and supports a high diversity of native plant species. The shrub layer is generally well developed, and there is a higher diversity of tree species in this area than in the Proposed Disturbance Area.

The Woodland formation in the Proposed Offset Areas exhibited mild disturbance with slight to moderate levels of grazing (predominately macropod) and some scattered signs of fire. Some areas of slight sheet erosion were recorded, while all areas contained a mild coverage of weed species.

Middle-aged and regenerating trees dominated this formation, with some areas of mature and old-growth trees. Woodland trees averaged a DBH of 169 mm. An average of 7.1 hollow-bearing trees per hectare was identified in this formation.

All four general layers of habitat, ground cover, understorey, mid-understorey and canopy were present across the Woodland formation. The canopy was typically 13 metres in height with a density of 23% canopy cover and typically comprised two main tree species. Narrow-leaved ironbark (*Eucalyptus crebra*) and slaty box (*Eucalyptus dawsonii*) were the two dominant tree species present in the canopy. Mild levels of dieback and moderate levels of mistletoe were present in the canopy.

Canopies on average contained a few bayonet branches and a few to moderate number of bare branches for bird perching sites. Hollow-bearing trees averaged a density of 7.1 trees per hectare within the woodland habitat areas. The distribution of individual tree hollow size classes averaged 2 small hollows (26-50 mm) per hectare, 14 medium hollows (51-100 mm) per hectare, 14 large hollows (101-300 mm) per hectare and two very large hollows (300+ mm) and no very small hollows (<25 mm).

The mid-understorey layer typically reached 4.9 metres in height with an average density of 21% cover of low trees and saplings. The understorey averaged 24% cover and typically contained five species reaching an average 1.6 metres in height. The ground cover averaged 32% cover comprised of an average 20 species, typically reaching 0.2 metres in height. Amongst the ground cover 50% of logs were solid with no bark and averaged a density of 380 logs per hectare. Stumps present amongst the ground cover and in the understorey layer were mainly solid stumps without bark and averaged a density of 73 stumps per hectare. Amongst the ground cover some areas of rock cover were present (4% of ground cover).

All general woodland habitat types for fauna species were present within the Woodland formation of the Proposed Offset Areas. The canopy provided perching, roosting and foraging habitat for canopy species and nesting or denning habitat for all but the smallest hollow-dependent species. The mid-understorey and understorey layers provide habitat for various bird and bat species that forage, perch, nest or roost below the canopy and above the ground layer. The ground layer provided habitat for species requiring either low vegetation or litter cover. Only small areas of rock cover occurred and no significant areas of rock cover for reptiles were present. Log and stump cover provided habitat small mammal and reptile and amphibian species.

6.2.1.3 Summary

The characteristics of the Woodland formation do not differ significantly between the Proposed Disturbance Area and Proposed Offset Areas. The differences in characteristics are generally the result of the presence of old growth vegetation within the Proposed Offset Areas, whereas it was not recorded within the Proposed Disturbance Area. The presence of this age class is likely to have influenced the higher average DBH of the vegetation of the Proposed Offset Areas, as well as the significantly higher hollow-bearing tree density. This is an important distinction between the two areas, as it highlights the increased value of the habitat within the Proposed Offset Areas to hollow-dependent species, particularly a number of the identified key threatened species. The higher diversity of tree species within the Proposed Offset Areas is also likely to increase the overall value of this habitat to key threatened fauna species.

The generally high level of fallen timber in the form of logs and stumps is likely to provide increased foraging potential for a number of key threatened species, particularly insectivorous woodland birds and terrestrial mammal species.

6.2.2 Riparian/Floodplain Formation

A summary of the vegetation and habitat values of the Riparian/Floodplain formation within the Study Area is shown in **Table 6.4**.

Table 6.4 – Summary of Condition Assessment Results for Riparian/Floodplain Formation

	Proposed Disturbance Area	Proposed Offset Areas
Total Area	53 hectares	31 hectares
Structure	Riparian/Floodplain woodland, usually comprising trees (15 m, 20% cover), mid-understorey (5-6 m, 20% cover), shrubs (2 m, 15% cover) and groundcovers (0.3 m, 50-90% cover)	Riparian/Floodplain woodland, usually comprising trees (10-12 m, 30-40% cover), mid-understorey (4-5 m, 25% cover), shrubs (1.5 m, 10% cover) and groundcovers (0.2 m, 90% cover)
Average Canopy Cover %	19%	33 %
Age/maturity	Predominantly middle-aged to mature woodland but with some areas of regeneration and old growth trees	Range of classes in some areas and regeneration and middle-aged trees dominant in other areas
Dominant Species	*Eucalyptus blakelyi, Angophora floribunda, Notelaea microcarpa* var*. microcarpa, Allocasuarina luehmannii, Aristida ramosa, Lomandra longifolia*	*Casuarina glauca, Lycium ferocissimum, Cynodon dactylon, Cheilanthes sieberi* subsp*. sieberi, Juncus acutus* subsp*. acutus*
Average DBH	206 millimetres	159 millimetres
Vegetation Health	Good, mild to moderate dieback and scattered mistletoe infestation	Good, some areas of mild dieback and moderate mistletoe infestation
Disturbance	Mild, no evidence of recent fire, slight to moderate levels of grazing, some areas of slight to moderate sheet erosion and slight to moderate weed infestation	Moderate, moderate levels of grazing, no signs of recent fire, most areas with slight rill/gully erosion and moderate weed infestation
Hollow-bearing Tree Average Density per hectare	9.4	0

6.2.2.1 Proposed Disturbance Area

The vegetation of the Riparian/Floodplain formation within the Proposed Disturbance Area is dominated by two main vegetation communities, which were substantially cleared between 40 and 70 years ago. Despite this, the riparian vegetation along the southern section of Anvil Creek has had a reasonable time to recover, having been cleared some time prior to the 1930s. As a result, it exhibits the greatest structural complexity. In general, the vegetation is in good health, and supports a high diversity of native plant species.

A total of 53 hectares of Riparian/Floodplain formation occurred within the Proposed Disturbance Area. Canopy cover averaged 19% and the average DBH was 206 millimetres. Most vegetation of the Riparian/Floodplain formation comprised middle-aged and mature trees but some areas of regeneration were recorded. Scattered old growth trees were also present within this formation. This formation also recorded an average of 9.4 hollow-bearing trees per hectare.

This vegetation formation exhibited a lack of recent fire evidence, low levels of grazing pressure, some areas of slight sheet erosion and slight to moderate weed infestation. In general, this formation displayed a mild level of disturbance.

All four general layers of habitat, being ground cover, understorey, mid-understorey and canopy were present across riparian habitat of the Proposed Disturbance Area. The canopy was typically 15 metres in height with a density of 19% cover, and typically comprised two main tree species. There were no signs of canopy mistletoe infestation in this habitat. On average, canopies contained a moderate to large number of bayonet branches, although there were few bare branches for bird perching sites. Hollow-bearing trees were recorded at a density of 9.4 hollow-bearing trees per hectare.

The mid-understorey layer typically reached 5.6 metres in height, with an average density of 19% cover of oak trees and saplings. The understorey averaged 15% cover and typically contained three species reaching an average 2.1 metres in height. The ground layer averaged 54% cover with an average 30 species typically reaching 0.3 metres in height. Amongst the ground layer, 60% of logs were solid with no bark and averaged 256 logs per hectare. Stumps present amongst the ground cover and in the understorey layer were mainly solid without bark and averaged 60 stumps per hectare. Some areas of rock cover were present amongst the ground layer.

All general woodland habitat types were present within the Riparian/Floodplain formation of the Proposed Disturbance Area. The canopy provided perching, roosting and foraging habitat for fauna species, as well as nesting or denning habitat for all but the largest hollow-dependent species. The mid-understorey and understorey layers provide habitat for the various bird and bat species that forage, perch, nest or roost below the canopy and above the ground layer. The ground layer provided habitat for species requiring either low vegetation or litter cover. Only small areas of rock cover occurred within this area, providing only small amounts of cover for reptiles. Log and stump cover provided habitat for small mammal, reptile and amphibian species.

Aquatic habitat in the Proposed Disturbance Area was limited to farm dams and ephemeral creek and drainage lines. Anvil Creek and Big Flat Creek are the two main creek lines within the Proposed Disturbance Area. Aquatic habitat in these creeks is described in **Section 7.1**. When not flowing, both creek lines contain isolated and relatively small shallow pools of still water. Aquatic and semi-aquatic species during non-flow conditions are likely to be limited to small fish species in the larger pools, as well as species able to move between isolated pools such as the snake-necked turtle (*Chelodina longicollis*) and frog species. Isolated pools provide a water source for fauna species during non-flow conditions.

Farm dams in the Proposed Disturbance Area had an average surface area of 0.26 hectares, with 89% of the surface area being clear of aquatic vegetation. An average of 42% of the circumference of these dams contained emergent reeds and sedges. Farm dams provided habitat for waterbirds, turtles, frogs and some reptiles. Farm dams also provide the main source of foraging habitat for the large-footed myotis (*Myotis adversus*).

6.2.2.2 Proposed Offset Areas

A summary of the vegetation and habitat values of the Riparian/Floodplain formation within the Proposed Offset Areas is shown in **Table 6.4**.

The vegetation of the Riparian/Floodplain formation within the Proposed Offset Areas is dominated by Swamp Oak Forest, which is a highly consistent and species-poor vegetation community. It has low structural complexity, and almost entirely comprises regrowth vegetation that is probably between 10 and 40 years old, although in some cases it may be over 40 years old. In general, the vegetation is in moderately good health, although weed invasion is problematic.

A total of 31 hectares of Riparian/Floodplain woodland occurred within the Proposed Offset Areas. Canopy cover averaged 33% and the average DBH was 159 millimetres. Areas of regeneration and middle-aged trees and other areas of regenerating trees were dominant. No hollow-bearing trees were recorded in this formation.

Moderate levels of disturbance were recorded in the Riparian/Floodplain formation, with moderate levels of grazing, slight rill/gully erosion and moderate levels of weed infestation.

The small area of Riparian/Floodplain formation relative to the larger areas of Woodland formations was the dominating factor contributing to the large reduction in habitat values between the two formations.

All four general layers of habitat, ground cover, understorey, mid-understorey and canopy were present across riparian areas in the Proposed Offset Areas. The canopy was typically 12 metres in height with a density of 33% canopy cover and dominated by a range of age classes of swamp oak (*Casuarina glauca*). There were no signs of canopy mistletoe infestation. The canopies contained a few bayonet branches and few to moderate amounts of bare branches for bird perching sites. Hollow-bearing trees averaged a density of 9.4 trees per hectare. The distribution of individual tree hollow size classes per hectare averaged 12 very small hollows (<25 mm), 19 small hollows (26-50 mm), 12 medium hollows (51-100 mm), 6 large hollows (101-300 mm) and no very large hollows (>301 mm).

The mid-understorey layer typically reached 4.5 metres in height with a density of 25% cover of low swamp oak trees and saplings. The understorey averaged 12% cover and typically contained three species reaching an average 1.6 metres in height. The ground cover averaged 90% cover and comprised an average 19 species typically reaching 0.2 metres in height. Amongst the ground layer, three quarters of logs were solid with no bark and averaged 190 logs per hectare. Stumps present amongst the ground layer and in the understorey layer were mainly solid with bark, and averaged 15 stumps per hectare. Some areas of rock cover were present within the ground layer.

All general woodland habitat types were present within the Riparian/Floodplain formation of the Proposed Offset Areas. The canopy was dominated by swamp oak in most areas but also contained scattered eucalypt species, some with hollows. Such features provide perching, roosting and foraging habitat for fauna species, as well as nesting or denning habitat for all but the largest of hollow-dependent species. The mid-understorey and understorey layers provide habitat for the various bird and bat species that forage, perch, nest or roost below the canopy and above the ground layer. The ground layer provided habitat for species requiring either low vegetation or litter cover. Only small areas of rock cover occurred. Log and stump cover provided habitat for small mammal and reptile and amphibian species.

Aquatic habitat in the Proposed Offset Areas was limited to farm dams and ephemeral drainage lines. Aquatic habitat in the Proposed Offset Areas is described in **Section 7.1**. Farm dams in the Proposed Offset Areas had an average surface area of 0.12 hectares, with 99% of the surface area clear of aquatic vegetation. An average of 26% of the circumference of the farm dams contained emergent reeds and sedges. Farm dams provided habitat for water birds, turtles, frogs and reptiles. Farm dams within the Proposed Offset Areas provide the main area of foraging habitat for the large-footed myotis (*Myotis adversus*).

6.2.2.3 Summary

The characteristics of the Riparian/Floodplain formation differ between the Proposed Disturbance Area and Proposed Offset Areas, mainly as a result of the presence of older vegetation, potentially old growth, only within the Proposed Disturbance Area. The vegetation of both areas contain a variety of age classes, with middle-aged to mature vegetation dominating in most areas. The presence of old growth vegetation is likely to create the increased average DBH of the vegetation of the Proposed Disturbance Area, as well as the relatively high number of hollow-bearing trees. The lower DBH of the vegetation of the Proposed Offset Areas, as well as the lack of hollow-bearing trees are characteristic of the generally younger vegetation, lacking areas of old growth vegetation. The increased canopy cover recorded within the Proposed Offset Areas is also likely to be a result of the generally younger vegetation, where there are fewer old growth trees displaying signs of senescence.

The most important characteristic of this vegetation formation is the high levels of hollow-bearing tree density recorded in the Proposed Disturbance Area. While no hollow-bearing trees were recorded within the Proposed Offset Areas, the Proposed Disturbance Area displays the highest level of hollow-bearing tree density within the entire Study Area. This identifies the Riparian/Floodplain formation of the Proposed Disturbance Area as being particularly important to hollow-dependent key threatened species.

6.2.3 Shrubland Formation

A summary of the vegetation and habitat values of the Shrubland formation within the Study Area is shown in **Table 6.5**. Shrubland only occurs in any abundance within the Proposed Offset Areas. Only 0.3 hectares was mapped in the Proposed Disturbance Area.

Table 6.5 – Summary of Condition Assessment Results for Shrubland Formation in the Proposed Offset Areas

Total Area	127 hectares
Structure	Shrubland, usually comprising trees (7-8 m, 15-20% cover), shrubs (1-2 m, 30-40% cover) and groundcovers (0.2 m, 40-60% cover)
Average Canopy Cover %	19%
Age/maturity	Most areas dominated by mature trees, some areas also contained middle-aged trees
Dominant Species	*Acacia binervia, Eucalyptus crebra, Notelaea microcarpa* var. *microcarpa, Beyeria viscosa, Kunzea* sp. 'Mt Kaputar', *Digitaria ramularis, Entolasia stricta*
Average DBH	167 millimetres
Vegetation Health	Excellent, rare mild dieback and no signs of mistletoe infestation. Mild fungal attack in scattered areas

Table 6.5 – Summary of Condition Assessment Results for Shrubland Formation in the Proposed Offset Areas (cont)

Disturbance	Mild, no signs of recent fire, areas of slight grazing, most areas with slight sheet erosion and all sites with mild weed infestation
Hollow-bearing Tree Average Density per hectare	2.1

6.2.3.1 Proposed Offset Areas

The vegetation of the Proposed Offset Areas Shrubland formation is dominated by three highly variable shrubland vegetation communities. It has moderate structural complexity, although some minor areas have probably been previously cleared, and regeneration in some areas is probably inhibited by goat grazing. The vegetation is in good health, and supports a high diversity of native plant species.

A total of 127 hectares of Shrubland occurs within the Proposed Offset Areas. Canopy cover averaged 19% and the average DBH was 167 millimetres. Most areas were dominated by mature trees with some areas also containing stands of middle-aged trees. An average of 2.1 hollow-bearing trees per hectare was recorded across Shrubland areas.

A lack of evidence of recent fire, low levels of grazing pressure, most areas of slight sheet erosion and slight weed infestation resulted in a mild level of disturbance in Shrubland formation areas.

The small area of Shrubland formation relative to the larger areas of Woodland formations was the dominant factor causing the large reduction in habitat values between the two formations.

Escarpment habitat is also a part of this vegetation formation. This occurs in the form of sandstone outcrops featuring exposed rock faces rising 50 to 100 metres above surrounding ground level, with vegetation on the plateau areas on top of these outcrops. In some parts, the plateau and slope areas contain significant amounts of rocky habitat. The rock outcrops contain cracks, overhangs and caves in at a range of heights and aspects.

The escarpment habitat areas within the Proposed Offset Areas provide specialist habitat for cave, overhang, crack and escarpment specialist species. Such fauna include cave roosting owls, cave/overhang/crack roosting bats, overhang nesting birds of prey and escarpment specialist macropod species such as rock wallabies. The escarpment habitat areas also provide habitat for reptile species requiring rocky habitat such as some broad-tailed gecko species.

6.2.3.2 Summary

The Shrubland formation only occurs within the Proposed Offset Areas. The main value of this vegetation formation comes from the foraging value of a number of nectar-producing shrub species to key threatened species, such as gliders. This vegetation formation would be most beneficial as fauna habitat where it adjoins woodland formations, where foraging species are able to descend from the canopy and forage in the mid-storey shrubs. The open nature of the shrublayer is also likely to benefit a number of threatened woodland bird species, as it provides an open mid-layer for foraging.

6.2.4 Grassland Formation

A summary of the vegetation and habitat values of the Grassland formation within the Study Area is shown in **Table 6.6**.

Table 6.6 – Summary of Condition Assessment Results for Grassland Formation

	Proposed Disturbance Area	Proposed Offset Areas
Total Area	934 hectares	871 hectares
Structure	Grassland, usually comprising groundcovers (0.4 m, 80-90% cover); trees and shrubs very sparse, in isolated clumps or absent	Grassland, usually comprising groundcovers (0.3 m, 70% cover); trees and shrubs very sparse, in isolated clumps or absent
Average Canopy Cover %	3%	0%
Age/maturity	Derived through previous clearing of woodland. Native and naturalised perennial and annual grasses and forbs of a variety of ages. Predominantly short-lived perennials. N/A, but where present all trees were regeneration	Derived through previous clearing of woodland. Native and naturalised perennial and annual grasses and forbs of a variety of ages. Predominantly short-lived perennials. N/A, but where present all trees were regeneration
Dominant Species	*Aristida ramosa, Austrostipa scabra, Dichanthium sericeum*	*Aristida ramosa, Austrostipa scabra, Dichanthium sericeum, Chloris ventricosa*
Average DBH	270 mm (average from only 2 trees present)	0
Vegetation Health	Generally in moderate to good condition, although significant bare areas and some erosion occurs in places	Generally in moderate to good condition, although significant bare areas and some erosion occurs in places
Disturbance	Moderate, moderate to severe levels of grazing, no signs of recent fire, some areas with slight sheet erosion and slight to moderate weed infestation	Moderate, no signs of recent fire, moderate to severe grazing, most areas with slight to moderate sheet and pedestal erosion and mild to severe weed infestation
Hollow-bearing Tree Average Density per hectare	0	0

6.2.4.1 Proposed Disturbance Area

The vegetation of the Grassland formation within the Proposed Disturbance Area comprises derived grassland, dominated by a range of native and naturalised perennial grasses and forbs. The health and integrity of the vegetation largely corresponds with the grazing history, particularly grazing intensity. Much of the Grassland was probably formed as a result of the clearing of woodland less than 70 years ago, although some areas may have been cleared well over 100 years ago.

The Grassland formation areas within the Proposed Disturbance Area exhibited moderate levels of disturbance, including moderate to severe levels of grazing (domestic stock and native animals), areas of slight sheet erosion and areas of slight to moderate weed infestation.

Grassland areas were dominated by grass species and contained small numbers of highly scattered trees. These scattered trees represented an average canopy cover of 3% and DBH of 270 mm. No hollow-bearing trees were recorded.

Only a single general habitat layer (this being groundcover) was present within this formation. Grassland habitat was typically 0.4 metres in height, comprising an average of 84% groundcover of various grass and forb species (an average of 36 species per site). All Grassland areas were subject to moderate to severe levels of grazing from domestic stock and/or native animals, particularly macropod species. Log cover predominantly comprised solid logs with no bark, which were recorded at an average density of 12.5 logs per hectare. Stump cover comprised stumps with central hollows, and these were recorded at an average density of 15.3 stumps per hectare. While the ground cover was dominated by grasses and forbs, a small percentage of this habitat layer comprised rock cover and areas of slight sheet erosion.

Fauna habitat for several species occurred within the Grassland formation. The grass and forb dominated ground cover containing log and stump cover provides habitat for grassland mammals (small and large), birds and terrestrial reptile species. The highly scattered trees throughout the Grassland provided nesting/roosting/perching habitat for bird species and shade for larger grazing mammal species.

6.2.4.2 Proposed Offset Areas

The vegetation of the Grassland vegetation formation of the Proposed Offset Areas comprises derived grassland, which is dominated by a range of native and naturalised perennial grasses and forbs. The health and integrity of the vegetation largely corresponds with the grazing history, particularly grazing intensity. Much of the Grassland was probably formed as a result of the clearing of woodland less than 70 years ago, although some areas may have been cleared well over 100 years ago.

The Grassland formation exhibited mild levels of disturbance, including mild levels of grazing from domestic stock and native animals, areas of slight sheet erosion and areas of mild weed infestation.

Grassland areas were dominated by grass species, with no hollow-bearing trees recorded during field sampling, although highly scattered trees did occur throughout the Grassland areas.

Grassland habitat was typically 0.3 metres in height comprising an average of 70% ground cover of various species of grasses and forbs (an average of 29 species per site). All Grassland areas were subject to severe levels of grazing from domestic stock and/or native animals (particularly macropod species). Logs and stumps were absent for Proposed Offset Areas Grassland areas. While the ground cover was dominated by grasses and forbs a small percentage of the ground layer comprised rock cover and areas of slight to moderate sheet erosion. Scattered trees were not recorded during grassland sampling.

The absence of log and stump cover within the Proposed Offset Areas grassland reduces the quality of habitat compared to the Proposed Disturbance Area. The Grassland formation provides habitat for large grazing mammals and terrestrial grassland bird species, however the absence of shelter in the form of logs and stump cover decreases the quality of the habitat for terrestrial grassland small mammal and reptile species.

6.2.4.3 Summary

The characteristics of the Grassland formation do not differ significantly between the Proposed Disturbance Area and Proposed Offset Areas. The majority of recorded habitat characteristics of the two areas are very similar, with the only major difference resulting from the presence of two trees within the results from the Proposed Disturbance Area. This resulted in a record for the average DBH for the Proposed Disturbance Area. Although the sites sampled in the Proposed Offset Areas did not record any trees, scattered trees are present in this area nonetheless. Slight differences in the structure of the Grassland were recorded, whereby the height and cover for the Grassland within the Proposed Disturbance Area were slightly higher than those of the Proposed Offset Areas.

While the value of this formation for key threatened species is low, the Grassland formation does provide open foraging areas, particularly in areas that lie on the fringes of existing vegetation. Such open areas in proximity to protective vegetated cover are likely to benefit woodland bird species, whereby short foraging periods would be spent in the Grassland with birds frequently returning to the protective cover of nearby woodland.

6.2.5 Threatened Fauna Habitat Value of Proposed Disturbance Area and Proposed Offset Areas

Section 3.6.4 detailed the method that was used to undertake a relative numerical assessment of the habitat values of the two areas for key threatened fauna species. These values should not be used in isolation and are only useful for comparative purposes. This process contributes to an overall understanding of the key factors involved in determining the value of fauna habitat.

Table 6.7 lists the individual scores for each key threatened species across the Proposed Disturbance Area and the Proposed Offset Areas.

Table 6.7 - Habitat Values for Key Threatened Species

	Potential Offsets Area	Proposed Disturbance Area
Hollow-dependent microbats	810	923
Cave-dependent microbats	723	912
Squirrel glider	760	868
Koala	747	993
Brush-tailed rock-wallaby	842	1036
Spotted-tailed quoll	847	1054
Powerful owl	716	849
Masked owl	879	1045
Barking owl	824	990
Brown treecreeper	848	953
Diamond firetail	990	1265
Grey-crowned babbler	919	1152
Speckled warbler	970	1250
Glossy black-cockatoo	747	954
Hooded robin	1006	1347

Table 6.7 shows that the habitat value of the Proposed Offset Areas is less than the habitat value of the Proposed Disturbance Area for all key threatened species. Habitat values for key threatened species in the Proposed Offset Areas ranged from 716 to 1006, while habitat values in the Proposed Disturbance Area ranged from 849 to 1347. In general, this indicates that the overall habitat available to key threatened species within the Proposed Offset Areas is of a lower value than that which is currently present in the Proposed Disturbance Area. An analysis of the formula used to derive the values (**Section 3.6.4**), however, shows that the key reason for this is the extent of area of Woodland habitat present in the two areas (1251 hectares in the Proposed Disturbance Area compared to 874 hectares in the Proposed Offset Areas). This is the single most important factor determining the final values.

6.2.6 Foraging Value of Proposed Disturbance and Proposed Offset Areas for the Large-footed Myotis (*Myotis adversus*)

A total of 34 farm dams were sampled during the field survey. On average the dams in the Proposed Disturbance Area were more than twice the size of those in the Proposed Offset Areas (**Table 6.8**). The average percentage open water between the two areas was similar while there was almost double the length of fringing reeds around dams in the Proposed Disturbance Area. Foraging values of 565 and 267 were calculated for the large-footed myotis (*Myotis adversus*) in the Proposed Disturbance Area and Proposed Offset Areas respectively.

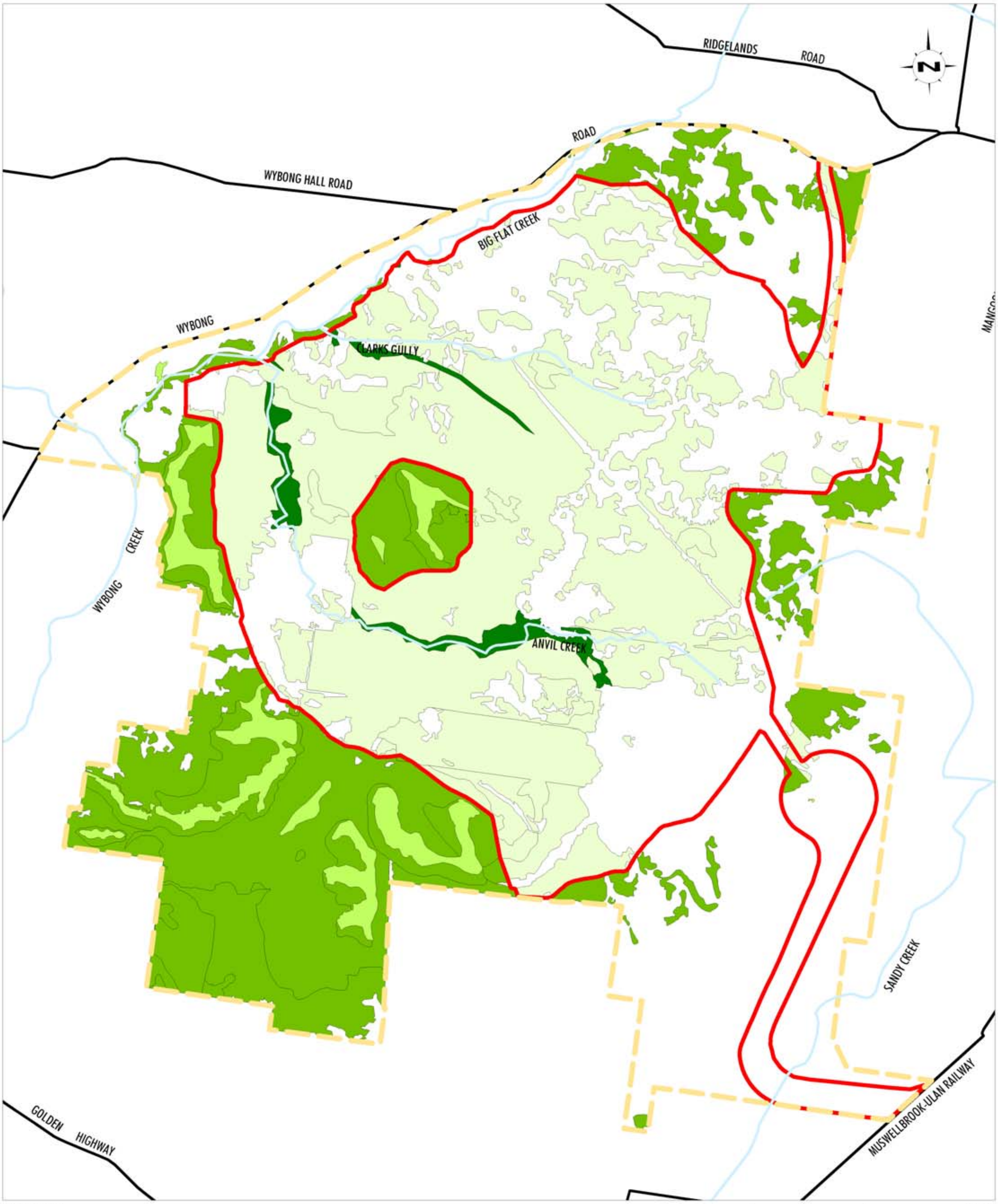
Table 6.8 - Proposed Disturbance Area and Proposed Offset Areas farm dam characteristics

	Number of dams sampled	Average surface area (m^2)	Average percentage open water	Average length of fringing reeds (m)
Proposed Disturbance Area	16	2611	90	70
Proposed Offset Areas	18	1228	93	43

6.2.7 Hollow Bearing Tree Density

Within each of the condition assessment sites, all trees were searched for the presence of hollows. Records were made on the size, orientation and location of hollows, where present. The random selection of the condition assessment sites resulted in a low number of hollow-bearing trees being assessed, relative to the anecdotal observations of the recorders, however this was an unavoidable outcome of the sampling process.

Hollow-bearing tree density varied significantly between vegetation formations (**Table 6.9** and **Figure 6.1**). Hollow-bearing tree density within the Woodland formation of the Proposed Offset Areas reached 7.1 hollow-bearing trees per hectare, while the Woodland of the Proposed Disturbance Area contained 1.6 hollow-bearing trees per hectare. The Proposed Disturbance Area Riparian/Floodplain formation contained the highest density of hollow-bearing trees, reaching 9.4 hollow-bearing trees per hectare, while no hollow-bearing trees were recorded during grid sampling in the Proposed Offset Areas Riparian/Floodplain areas. While no hollow-bearing trees were recorded during sampling in the Proposed Offset Areas Riparian/Floodplain formation, hollow-bearing trees are known to occur in such areas. No hollow-bearing trees were recorded in the Grassland areas of either the Proposed Disturbance Area or Proposed Offset Areas. Hollow-bearing trees reached a density of 2.1 hollow-bearing trees per hectare in the Proposed Offset Areas Shrubland areas, and no Shrubland areas occurred within the Proposed Disturbance Area.



Source:

Legend

- Proposed Disturbance Area
- Study Area
- 1.6 Hollow-Bearing trees per Hectare
- 2.1 Hollow-Bearing trees per Hectare
- 7.1 Hollow-Bearing trees per Hectare
- 9.4 Hollow-Bearing trees per Hectare

FIGURE 6.1

Hollow-Bearing Tree Density

Table 6.9 – Hollow-bearing Tree Density in the Study Area

	Hollow-bearing Trees per Hectare	
	Proposed Disturbance Area	**Proposed Offset Areas**
Woodland	1.6	7.1
Riparian/Floodplain	9.4	0
Grassland	0	0
Shrubland	N/A	2.1

The number of hollow-bearing trees and the sizes of hollows contained within them varied across the four vegetation formations containing hollow-bearing trees (**Table 6.10**). The provision of potential habitat for particular species can be further investigated through an assessment of the size classes of hollows present within hollow-bearing trees. Very small tree hollows (less than 25 millimetres in diameter) provide potential habitat for bat, reptile and amphibian species. Small tree hollows (between 26 and 50 millimetres in diameter) provide potential habitat for insectivorous bats, small birds and small gliders well as reptile and amphibian species. Medium sized hollows (between 51 and 100 millimetres in diameter) provide habitat for many species such as possums and medium sized birds. Large tee hollows (between 101 and 300 millimetres in diameter) provide potential habitat for species such as possums and large birds. Very large tree hollows (greater than 301 millimetres diameter) provide potential habitat for species such as possums and large birds.

Table 6.10 - Hollow Size Distribution

		Proposed Disturbance Area Woodland	**Proposed Disturbance Area Riparian**	**Proposed Offset Areas Woodland**	**Proposed Offset Areas Shrubland**
Number of survey sites		16	8	14	12
Total number of hollow-bearing trees identified		1	3	4	1
Hollows Per hectare	**Very Small (<25 mm)**	0	12.5	0	2.1
	Small (26-50 mm)	3.1	18.8	1.8	2.1
	Medium (51-100 mm)	1.6	12.5	14.3	0
	Large (101-300 mm)	3.1	6.3	14.3	0
	Very Large (>300 mm)	0	0	1.8	0

Note there were no hollows recorded at the sampling sites in the Proposed Disturbance Area Grassland or Proposed Offset Areas Grassland areas, or the Proposed Offset Areas Riparian/Floodplain area, and there was no shrubland in the Proposed Disturbance Area.

A single hollow-bearing tree was identified during the Proposed Disturbance Area Woodland formation sampling at 16 sites. The single tree contained 5 hollows and represented 3.1 small, 1.6 medium and 3.1 large hollows per hectare. A higher density of tree hollows were identified in all size classes of the Proposed Disturbance Area Riparian/Floodplain formation with up to 18.8 small sized hollows per hectare. No very large hollows were identified in either the Proposed Disturbance Area Woodland or Riparian/Floodplain formations. No very small sized hollows were identified in the Proposed Offset Areas Woodland formation. Low densities of small and very large and high densities of medium and large sized hollows were identified in the Proposed Offset Areas Woodland formation. The Proposed Offset Areas Shrubland formation contained only very small and small sized tree hollows, as no medium or large hollows were identified.

6.3 Summary

Despite the more restricted area of fauna habitat available in the Proposed Offset Areas, there is a general higher quality of habitat present for most of the key threatened fauna species, except in the Riparian/Floodplain formation, where the relative quality of the habitat is substantially poorer.

7.0 Aquatic Results

The Study Area is drained by two major drainage lines, being Anvil Creek and Clarks Gully. There catchments flow into Big Flat Creek, which flows along the northern boundary of the Study Area, within the Proposed Offset Areas. Additional drainage lines of the Study Area include Wybong Creek which adjoins the north-western corner of the Study Area, and Sandy Creek which adjoins the south-eastern corner of the Study Area (**Figure 3.5**). A number of dams were identified within the Study Area, especially in the upper reaches of the drainage lines. These also provide habitat for aquatic flora and fauna. The creek beds and banks of the Study Area are generally sandy, with mobile eroded sands and some gravels. The creeks generally flow during storm events or extended rain periods, washing much eroded sediment downstream.

Due to a low flow regime, the creeks within the Proposed Disturbance Area provide limited habitat for fish species, however small riffle-dwelling native fish such as gudgeons (Eleotridae family) may occur in the Proposed Disturbance Area during periods of moderate flow. Fish habitat is also limited by the presence of the introduced predator mosquito fish (*Gambusia holbrooki*), which was identified within the Big Flat Creek and Wybong Creek catchments.

7.1 Aquatic Habitats of Study Area

7.1.1 Anvil Creek

Anvil Creek is a major tributary of Big Flat Creek and originates and flows through the Proposed Disturbance Area. Anvil Creek is characterised by a well defined channel with an average width of approximately 20 metres, ranging from five metres in the upper reaches to 22 metres in downstream areas. Bank heights range from one metre to three metres with moderate to very steep grades. Erosion was evident within the creek system with undercutting of outer bends recorded.

Anvil Creek is bordered by flats of Forest Red Gum Riparian Woodland for most of its length, as well as Rough-barked Apple Woodland at its confluence with Big Flat Creek.

The upstream reaches of Anvil Creek lack habitat diversity, with no refuge pools or pool/riffle sequences recorded. Downstream areas of the creek contain pool/riffle sequences, refuge pools, in-channel woody debris and increased levels of shading ranging from 25% to 40% compared to 10% at upstream (**Figure 3.5**).

7.1.2 Clarks Gully

Clarks Gully is a minor tributary of Big Flat Creek, occurring in the north-east of the Proposed Disturbance Area. Clarks Gully does not support well-defined riparian vegetation; rather it occurs within terrestrial communities, indicating its highly ephemeral nature. Despite this, a narrow band of Forest Red Gum Riparian Woodland was mapped along its course, although this community is not truly riparian in this location. Some pools were evident along the creek, along with pool/riffle sequences.

Clarks Gully ranges from narrow widths to those in excess of 35 metres. In the widest reaches of the system, multiple low flow channels are evident, with terrestrial vegetation and trees growing within the channel. The channel is well vegetated by terrestrial species with the limited sedge and rush vegetation indicating the intermittent flow regime of the creek. Bank heights were generally one to three metres and little evidence of erosion was observed.

7.1.3 Big Flat Creek

Big Flat Creek flows along the northern boundary of the Study Area, within the Proposed Offset Areas. The creek supports generally well developed riparian vegetation dominated by swamp oak (*Casuarina glauca*). In-channel vegetation is dominated by the weed sharp rush (*Juncus acutus* subsp. *acutus*), common reed (*Phragmites australis*) and bullrush (*Typha orientalis*). Some submerged aquatic species were also recorded in low flow pools. The creek is well defined, with channel widths in the order or 20 metres (range 7 metres to 30 metres) with bank heights generally being one metre. Minor erosion of banks and the channel was recorded, and salt scalding of the adjacent floodplain was evident.

A range of instream aquatic habitats were recorded including pools up to 25 metres in length, pool/riffle sequences, woody debris and detritus. Big Flat Creek provided habitat for significant numbers of small fish such as mosquito fish (*Gambusia holbrooki*).

7.1.4 Wybong Creek

Wybong Creek is the major watercourse in the local area, and is the most eastern of the northern tributaries of the Goulburn River. The headwaters of the catchment are located in the Liverpool Ranges to the north (Kovac & Lawrie 1991) and a narrow strip of alluvial fill composed of sand or boulders with minor clay lenses is associated with the creek. The width of the channel is between 25 metres and 40 metres in the sections surveyed and bank height ranged from 2.5 metres to in excess of 20 metres.

Wybong Creek exhibited the greatest diversity of habitats of all drainage systems surveyed as part of this assessment. Low flows were recorded in the creek, with low to moderate water levels present. Pool and run habitats were common, with pool/riffle sequences evident in the low flow channel. Overhanging riparian vegetation was recorded and macrophyte cover ranged from 50% to 60%. Fallen woody debris and snags were also recorded.

The sites surveyed as part of the assessment showed little evidence of active erosion.

7.1.5 Sandy Creek

Sandy Creek is a fifth order tributary of the Hunter River, extending for some 36.8 kilometres from its headwaters in the north to its confluence with the Hunter River in the south of the catchment area. The catchment of Sandy Creek covers an area of approximately 14,400 hectares, and includes floodplain areas, grazing land, woodland and urban areas such as the township of Denman.

Slopes within the catchment vary from approximately 1% in low lying floodplain areas in the south of the catchment, to up to 63% in the upper slopes in the north of the catchment, including those surrounding Black Jack Mountain and Bells Gap in the north-west of the catchment and Smearers Hill in the north.

Sandy Creek occurs within grazing land in the areas surveyed as part of the assessment, with no defined riparian vegetation recorded. Pools were identified within the creek, however no flow was recorded. Habitat complexity was considered to be low with no pool/riffle sequences, woody debris, meander bends or shading recorded.

Sandy Creek was found to range from narrow widths to in excess of 20 metres. The channel is well vegetated with grasses, with limited sedge and rush vegetation recorded, indicating the intermittent flow regime of the creek. Bank heights were generally one to three metres and little evidence of erosion was identified.

Additional minor drainage lines within the Proposed Offset Areas are first order drainage lines that generally lack defined channels, riparian vegetation and aquatic habitats. Flows are only established following rain events and there is no water storage capacity within these drainage lines.

7.2 Aquatic Flora

The Proposed Disturbance Area supports very limited aquatic vegetation with low species diversity. This vegetation was not mapped as a separate community due to the very limited extent of the association and the scale of vegetation mapping; rather it is included as a component of the terrestrial vegetation.

Most creeklines of the Study Area support vegetation that prefers moist or waterlogged soil. Along the edges of most semi-permanent ponds along the three major creeks (Anvil Creek, Big Flat Creek and Clarks Gully), a variety of sedges, rushes and forbs were present. The introduced sharp rush (*Juncus acutus* subsp. *acutus*) was the dominant sedge species recorded within the channel of each of the three major creek systems, often forming dense infestations.

Anvil Creek and Clarks Gully generally lack the habitats required to support wetland and aquatic flora species. The introduced sharp rush was the dominant species recorded in the creek channel, with dense infestations recorded. Other species, recorded in low numbers, included *Eleocharis* sp. and *Juncus* sp.

Big Flat Creek supports the greatest range of aquatic species recorded during the aquatic flora survey due to the permanent nature of the creek. Commonly recorded species included common reed (*Phragmites australis)* and cumbungi (*Typha orientalis)* in addition to the introduced sharp rush. Fennel pondweed (*Potamogeton pectinatus*) and water milfoil (*Myriophyllum aquaticum*) were identified in habitats present at Site 14 (**Figure 3.5**).

Wybong Creek supports a range of aquatic species due to the prevalence of refuge pools during low flow periods. Commonly recorded species included fennel pondweed, *Potamogeton perfoliatus,* curly pondweed (*Potamogeton crispus*)*,* Pacific azolla (*Azolla filiculoides*)*,* water milfoil, cumbungi*, Cyperus* sp*.* and the introduced elodea *(Elodea canadensis).*

Sandy Creek is highly disturbed and often lacks a distinct channel, preventing the development of complex aquatic and wetland communities. Cumbungi was recorded in Sandy Creek.

The Proposed Disturbance Area supports over 20 dams, ranging from small, steep-sided dams through to larger bodies with shallow sides. In all cases, however, the aquatic vegetation occurring within and fringing the dams were found to be very species poor, and frequently very sparsely distributed. This was most likely as a result of stock grazing, with cattle having uncontrolled access to all dams that were inspected. Common species recorded in farm dams included swamp lily (*Ottelia ovalis*), *Eleocharis* sp*., Potamogeton ochreatus, Potamogeton pectinatus* and *Juncus* sp*.*

A list of aquatic flora species recorded in the Study Area is provided in the flora species list in **Appendix E**.

7.3 Aquatic Fauna

A total of 24 aquatic fauna species were recorded during the aquatic survey of the Study Area and surrounds, comprising three vertebrate and 21 invertebrate species. Of these, 15 species were recorded from the Proposed Disturbance Area, no species were recorded from the Proposed Offset Areas and 11 species were recorded from surveys completed along Wybong Creek, outside of the Study Area.

7.3.1 Aquatic Invertebrates

Aquatic invertebrates are sensitive to changes in flow regime, water quality and habitat condition. As a result of this, they are frequently used as biological indicators of waterway health and to assess impacts on freshwater ecosystems. The diversity, composition and abundance of macro-invertebrate communities provide a general measure of the ecological health of waterways.

Twenty-one families of macroinvertebrates were identified during the aquatic survey. Seventeen of the 21 species are regarded as being tolerant to very tolerant of environmental stress, with only three of the recorded species being considered sensitive.

The diversity of macroinvertebrate species was generally greater within Wybong Creek than within the Proposed Disturbance Area due to the presence of a more permanent water source. This trend may be attributed to greater habitat complexity and provision of a variety of microhabitats within the Wybong system. The ephemeral nature of the creeks and drainage lines within the Study Area limits the diversity and density of aquatic organisms.

The results indicate a marked difference between the habitats of the Study Area in comparison with the more permanent Wybong Creek, which provides a significantly greater level of aquatic habitat. As shown in **Table 7.1**, species identified from Wybong Creek account for approximately 52% of species recorded during surveys. Twenty-eight per cent of species were recorded in Wybong Creek alone.

Table 7.1 - Invertebrate Families Recorded within the Study Area

			Sampling Location Identified		
FAMILY NAME	**COMMON NAME**	**Tolerance Rating**	**Proposed Disturbance Area**	**Proposed Offset Areas**	**Outside of Study Area**
Atyidae	freshwater shrimp	Tolerant	-	-	18, 19
Telephlebiidae	aeshnid-like dragonfly	Tolerant	-	-	18, 19
Physidae	snail (introduced)	Very tolerant	11	-	18, 19
Lymnaeidae	pond snail	Very tolerant	-	-	19
Hydrobiidae	snail	Very tolerant	8	-	-
Sphaeriidae	pea shells	Sensitive	4	-	-
Oniscigastridae	mayfly	Very Sensitive	11	-	18, 19
Elmidae	riffle beetle	Tolerant	-	-	19
Notonectidae	backswimmers	Very tolerant	6	-	-
Protoneuridae	damselfly	Tolerant	6, 11	-	18, 19
Chrionomidae	non-biting midges	Tolerant	4	-	18
Caenidae	mayfly	Very Sensitive	-	-	18
Hydroptilidae	Microcaddis (caddisfly)	Sensitive	-	-	18

Table 7.1 - Invertebrate Families Recorded within the Study Area (cont)

			Sampling Location Identified		
FAMILY NAME	**COMMON NAME**	**Tolerance Rating**	**Proposed Disturbance Area**	**Proposed Offset Areas**	**Outside of Study Area**
Mecoptera	scorpionfly larvae	Tolerant	11	-	-
Corixidae	water boatmen	Very tolerant	4, 6, 11,	-	-
Dytiscidae	diving beetle	Very tolerant	11	-	-
Culicidae	mosquito larvae	Very tolerant	8, 11,	-	-
Muscidae	muscids	Very Tolerant	11	-	19
Hirudinea	leeches	Very Tolerant	11 (dam)	-	-
Parastacidae	freshwater crayfish	Tolerant	6	-	-
Aeshnidae	dragonfly	Tolerant	6	-	-

Note: Tolerance Rating sourced from Department of Land and Water Conservation (2000)

The most commonly encountered species included the damselfly nymph, mayfly nymph, the introduced Physidae snail and water boatmen. All of these species are considered to be very tolerant or tolerant of pollution and poor water quality, with the exception of the mayfly nymph, which is considered to be very sensitive to disturbance and pollution. This species was recorded at two sites on Wybong Creek and in a dam on a tributary of Big Flat Creek (refer to **Figure 3.5**). The species was recorded in low densities with one specimen recorded from each sampling site in Wybong Creek and two from Site 11.

Macroinvertebrate species were recorded from two sites along Anvil Creek and in one sampling location on Clarks Gully. A total of nine invertebrate species were recorded from a dam in the upper reaches of Clarks Gully, which was the most species rich habitat sampled within the Proposed Disturbance Area. Two families were recorded within Clarks Gully, with low numbers of each species recorded.

Anvil Creek supported a total of seven families with backswimmers (Family: Notonectidae) the most common species recorded. A freshwater crayfish (*Cherax destructor*) was recorded in a low flow refuge pool in Anvil Creek.

7.3.2 Aquatic Vertebrates

Three aquatic vertebrates were recorded during sampling. The introduced mosquito fish (*Gambusia holbrooki*) was recorded in low flow refuge pools in Big Flat Creek at sampling Site 13 and also in pools at Sites 16 and 18 along Sandy Creek and at Site 22 on Wybong Creek. Wybong Creek also provided habitat for the freshwater mullet (*Myxus petardi*) and eastern snake-necked turtle (*Cheladonia longicollis*). The eastern snake-necked turtle was recorded in high numbers in suitable habitat within the Proposed Disturbance Area, with records at a dam at Site 2 and at Site 11. The species was also recorded opportunistically during other aspects of the ecology survey at numerous dams within the Proposed Disturbance Area. The numerous farm dams within the Proposed Offset Areas provide only a limited area of permanent aquatic habitat.

Short-finned eels (*Anguilla australis*) are expected to occur in farm dams across the Study Area.

7.3.3 Threatened Aquatic Species

The Hunter River catchment does not provide habitat for any of the listed threatened aquatic species, populations and endangered ecological communities listed under the *Fisheries Management Act* 1994.

No threatened aquatic species were recorded during the assessment and none are expected to occur.

8.0 Potential Impacts of the Project

8.1 Introduction

This section provides details on the likely impacts of the Project on threatened species, endangered populations, endangered ecological communities, or their habitats, within the Study Area during and beyond the life of the mine. This section identifies a number of modifications that were made to the original Project design in order to reduce potential impact on particular threatened species and ecological features of the Study Area. These modifications are included within the final Project design and thus have been considered within the following impact assessment.

Following is a discussion of the potential impacts of the Proposal, including the likely impacts on vegetation communities, fauna habitat, aquatic species, and their habitat, and the results of the legislative impact assessments according to the EP&A Act 1979 and EPBC Act 1999.

The section concludes with a summary of the likely overall impact of the Project, when considering the modifications included within the final Project design, but not including any mitigation. This also includes discussion on the impact of the Proposal and how this relates to the overall goal outlined in DoP's Director-General's requirements of no net loss of flora and fauna values in the area in the medium to long term.

The impact assessments contained within this section were completed in accordance with the "Threatened Species Assessment Guidelines" (DEC 2005), meaning that the impact assessments contained within this Section, as well as within the Test for Ecological Significance (**Appendix F**), do not include consideration of the mitigation, ameliorative or offset measures proposed as part of this Project (see **Section 9**). Rather, the impact assessments described in this section, as well as in **Appendix F**, are based purely on the expected effect that the Project will have on the ecological features of the Study Area.

While not considered as part of the impact assessment, a detailed Biodiversity Offset Strategy has been developed and included as an integral component of this Project. This package has been designed to address the likely impacts on key threatened species within the Study Area, and is described in detail in **Section 9**.

8.2 Modifications during Project Planning

A number of modifications are included within the final design of the Project in order to reduce the overall impact on particular threatened species and ecological features of the Study Area. In some cases, these modifications were developed and included as a result of specific ecological factors, whereas other modifications were included for design-related reasons, however their inclusion into the Project design still provided an overall ecological benefit. Examples of modifications included into the final Project design include:

- Reduction in the Proposed Disturbance Area boundary around Anvil Hill to allow for increased retention of a stand of drooping sheoak (*Allocasuarina verticillata*) as an important known feed tree for the glossy black-cockatoo (*Calyptorhynchus lathami*) within the Study Area;

- Reduction in the Proposed Disturbance Area boundary around the bases of Anvil Hill and Wallaby Rocks in order to reduce potential for blasting impacts on potential roosting areas for cave-dependent micro-bats;

- Reduction in the Proposed Disturbance Area boundary along the floodplain of Big Flat Creek, in order to remove this waterway from potential disturbance, as well as to protect the associated floodplain vegetation communities, a number of which are considered to be regionally significant by Peake (2006). The removal of this area from the Proposed Disturbance Area also allowed for the formation of an important internal corridor to protect and enhance the existing vegetated linkage from north-eastern parts of the Study Area to the west;

- Agreement to protect significant ecological features within the Proposed Offset Areas, such as a number of small populations of *Acacia pendula* (listed as a endangered population, as well as an integral part of a listed EEC);

- Agreement to significantly increase the ecological survey effort (as part of a positive feedback loop) in response to the outcomes of progressive surveys. Such increases in survey effort have included:

  - Targeted habitat searches following identification of scats from the brush-tailed rock-wallaby (Petrogale penicillata). These searches targeted likely habitat to further investigate the presence/absence of this species within the Study Area, including further scat searches, as well as searches for further evidence of an extant population;

  - Extensive hair funnel/tube surveys to target the presence/absence of the squirrel glider (*Petaurus norfolcensis*) and spotted-tailed quoll (*Dasyurus maculatus maculatus*) across the Study Area;

  - Provision of assistance to the Royal Botanic Gardens and Melbourne for their ex-situ conservation program for *Pomaderris reperta*; and

  - Development of an extensive condition assessment process to allow detailed quantitative description and comparison of habitat features and quality between the Proposed Disturbance Area and Proposed Offset Areas.

These modifications to the original Project design contributed to a reduction in the impact of the Project on the ecological features of the Study Area. As these modifications have been included as part of the final Project design, they have been considered when determining the level of impact posed by the Project. The potential (and likely) impacts of this final Project design are discussed below.

8.3 Potential Ecological Impacts of the Project

Without mitigation, the Anvil Hill Project has the potential to result in a variety of impacts on the ecological features of the Study Area. The majority of these impacts will be direct impacts from the establishment and construction of the mine, however there are also likely to be ongoing impacts as a result of the operation of the mine. The potential consequences of such impacts are discussed further within the Test for Ecological Significance (**Appendix F**) in reference to species listed under the NSW TSC Act, and Assessment of Significance (**Appendix G**) under the EPBC Act 1999. The potential occurrence and consequences of these impacts are also discussed further in the following subsections of this report. Additionally, a detailed impact mitigation strategy is proposed in order to reduce the potential incidence and consequences of these impacts. This strategy is outlined in detail within **Section 9** of this report.

Potential direct impacts from the construction of the mine would include, but may not be limited to:

- **Clearance of vegetation:** the clearing of vegetation will pose the most important impact from the Project. This impact will come from the direct removal of flora and vegetation communities and their habitat, as well as the removal of foraging and breeding habitat for fauna. For the purposes of this assessment, it has been assumed that all vegetation communities and flora within the Proposed Disturbance Area will be removed for the mine construction and operation. This removal of vegetation within the Proposed Disturbance Area is likely to reduce the level of flora biodiversity within the Study Area and has the potential to do so with fauna also.

- **Isolation/fragmentation and increased genetic isolation:** the clearing of vegetation within the Proposed Disturbance Area will increase the levels of fragmentation and isolation of the Study Area. A secondary impact from increased isolation and fragmentation results from a reduced gene flow throughout the landscape. Limited genetic flow into or out of a particular area can lead to reduced genetic variation and inbreeding depression within flora and fauna species. This can lead to isolated populations being placed at increased risk of extinction due to a reduced ability to cope with stochastic events and environmental change. For the above reasons, corridor linkages have been proposed and are addressed in **Section 9**.

- **Recruitment/dispersal:** an increase in isolation and fragmentation is also likely to reduce genetic exchange due to the restrictions isolation places on recruitment and dispersal for many species. This a particular threat to fauna species with limited ability to cross large open areas. This limits the ability of young to disperse from the parental home range to establish their own territory, thus spreading genetic material throughout the landscape. Similarly, fragmentation and isolation inhibits the potential for some species to colonise new areas and establish satellite populations.

In addition to the potential impacts associated with the construction and establishment of the Project, the potential for ongoing operational impacts must also be considered. Such impacts may be those created by the everyday operation of the mine, and could include impacts from:

- **Pollination vectors:** many plant species rely on pollination vectors such as insects and birds to transfer genetic material between individual plants and populations. Increased fragmentation and isolation can reduce the ability of these pollination vectors to travel between populations, thus impacting the reproductive success of some plant species.

- **Increased competition for resources:** the removal of large areas of habitat for fauna species will create the need for individuals to disperse into new areas and compete with existing residents for foraging, roosting and breeding resources. Such resources will include suitable hollows, territories and home ranges, mates and other habitat features such as specific feed species and foraging resources. Where the habitat is isolated, overcrowding can occur, further exacerbating conflict for resources. Increased competition is likely to cause the death of individuals, either due to direct conflict, resulting injuries or starvation.

- **Disease:** the incidence of disease is often increased when normal population thresholds are pressured, and overcrowding occurs. This is particularly so with fauna species, when overcrowding facilitates the rapid spread of some diseases throughout a population.

- **Increased threat of death:** the removal of habitat within the Proposed Disturbance Area will increase the potential for fauna deaths due to vegetation clearing. This would be particularly true for hollow-dependent species. The significant increase of vehicle usage within the Study Area is also likely to increase the potential for vehicle collisions with fauna species. The proposed rail loop is also likely to increase the potential for death or injury from vehicle collision.

- **Human interaction:** the increased presence of humans within the Study Area may cause disturbances to flora and fauna species. Increased usage of the Study Area is likely to increase the incidence of human-induced impacts such as damage to vegetation from vehicles or trampling, increased rubbish and alteration to normal behaviour patterns due to human presence.

- **Operational impacts:** include impacts from operational activities, such as disturbance to normal behaviour patterns due to noise, vibration, lighting or dust. Such disturbances may cause areas of previously suitable habitat to become sub-optimal, and may cause fauna species to vacate areas of previously suitable habitat.

- **Edge impacts:** many native species are known to be sensitive to edge effects. Such edge effects result in deterioration of the quality of vegetation as habitat along the interface with cleared or disturbed environments. Such habitat deterioration can result from impacts such as increased weed invasion, rubbish, increased predation, increased presence of introduced species or increased human presence. The clearing of vegetation within the Proposed Disturbance Area will increase edge effects to large amounts of remaining vegetation.

- **Introduced species:** importation of materials to the Study Area, management activities, increased human presence and clearing of vegetation all have the potential to increase the incidence of introduced species within the Study Area. Weed species may be brought into the Study Area with imported materials, or encouraged by removal of native vegetation. Introduced fauna species such as foxes, rabbits and feral cats may increase within the Study Area due to the alteration in land use. An increase in introduced species within the Study Area could have considerable impacts on existing native species.

8.4 Conceptual Project Staging

The construction and operation of the mine will be progressive, as will the rehabilitation, which is designed to achieve the post-mining final land use objectives of creating a stable final landform featuring self-sustaining indigenous vegetation communities. The key stages of the conceptual mine plan, together with the status of progressive vegetation disturbance and rehabilitation, is outlined below:

- **Year 2** – including the establishment of infrastructure such as access roads, rail loop, facilities, ROM Pad, product stockpiles, coal preparation plant, tailings dam. This stage will involve the establishment and initial workings of the main pit, southern pit and northern pit, as well as the tailings pit.

  Approximately 1078 hectares of existing vegetation will require clearing up until Year 2. The Disturbed Grassland and Ironbark Woodland Complex vegetation communities will be subject to the majority of this impact with 607 and 471 hectares requiring clearing, respectively.

- **Year 5** – including the progression of the main, northern and southern pits, as well as the tailings pit. Areas of rehabilitation will be established within the main pit and northern pit. The tailings dam will consist of active tailings in this stage of the mine progression.

  The additional clearing required for this stage will equate to approximately 212 hectares, mainly consisting of the Ironbark Woodland Complex (108 hectares) and Disturbed Grassland (67 hectares) vegetation communities. As part of this stage, approximately 94.3 hectares of shaped final landform will be available for revegetation.

- **Year 10** – will include the progression of the main, northern and southern pits. In this stage, the tailings dam will consist of inactive tailings, and the tailings pit will consist of areas of active and inactive tailings.

  Additional clearing required for this stage will equate to 408 hectares, mainly of Ironbark Woodland Complex (169 hectares) and Disturbed Grassland (125 hectares) vegetation communities. Large areas of reshaped final landform will be available for revegetation within the northern pit, with smaller areas becoming available in the main pit (288.1 hectares). The first areas available to revegetation and regeneration in the southern pit will become available during this stage.

- **Year 15** – will include the progression of the main and southern pits, however this stage will see the completion of extraction works within the northern pit. The tailings pit will still contain areas of active and inactive tailings.

  The addition of approximately 838 hectares of revegetated land will see over half of the main pit reformed and subject to revegetation and regeneration, and the majority of the southern pit added to the progressive revegetation and regeneration areas. This stage will also see the revegetation and regeneration of the tailings dam.

- **Year 20** – this stage will see the completion of extraction activities within the main and southern pits. Areas of overburden emplacement will remain within the main and southern pits at this stage, as well as a small area of active pit within the main pit.

  Areas of reformed land will be added to the revegetation and regeneration areas within the main pit and southern pit (1227 hectares), as well as the first areas available within the tailings pit. Approximately half of this pit will still contain active and inactive tailings at this stage.

- **Year 21**– mine closure.

Table 8.1 provides details on the required clearance of each vegetation community within the Proposed Disturbance Area. It provides a quantification of the impact of each mine stage in relation to vegetation clearing requirements, and the individual impacts on each vegetation community. A percentage value of cumulative loss for each vegetation community is provided for each mine stage (as a percentage of the potential clearance area within the Proposed Disturbance Area).

Table 8.1 - Required Clearance of Vegetation Communities per Mine Stage

	Mine Stage (Year) and clearing of vegetation from the Proposed Disturbance Area										
Vegetation Formation and Community	**Proposed Disturbance Area (ha)**	**Year 2**	**% Cleared (Cumulative)**	**Year 5**	**% Cleared (Cumulative)**	**Year 10**	**% Cleared (Cumulative)**	**Year 15**	**% Cleared (Cumulative)**	**Year 20**	**% Cleared (Total)**
Woodland	**1250.8**	**471.2**	**37.7**	**140.5**	**48.9**	**280.9**	**71.4**	**219.7**	**88.9**	**138.5**	**100**
Slaty Box Woodland	245.0	100.7	41.1	28.3	52.7	89.4	89.2	18.4	96.7	8.1	**100**
Ironbark Woodland Complex	886.3	328.9	37.1	107.9	49.3	168.9	68.4	157.6	86.1	122.9	**100**
Bulloak Woodland	99.5	30.7	30.8	0.0	30.8	18.6	49.5	43.8	93.5	6.5	**100**
Drooping Sheoak Woodland	0.8	0.0	0.0	0.0	0.0	0.8	100.0	0.0	100.0	0.0	**100**
Paperbark Woodland	19.2	10.8	56.5	4.2	78.4	3.3	95.4	0.0	95.4	0.9	**100**
Riparian/Floodplain	**52.6**	**22.1**	**42.1**	**3.9**	**49.5**	**2.6**	**54.5**	**21.0**	**94.3**	**3.0**	**100**
Swamp Oak Riparian Forest	1.0	0.6	56.9	0.0	56.9	0.4	100.0	0.0	100.0	0.0	**100**
Rough-barked Apple Woodland	0.3	0.1	45.2	0.0	45.2	0.2	106.5	0.0	106.5	0.0	**100**
Forest Red Gum Riparian Woodland	51.3	21.4	41.7	3.9	49.4	2.0	53.2	21.0	94.1	3.0	**100**
Shrubland	**0.2**	**0.0**	**0.0**	**0.0**	**0.0**	**0.2**	**100.0**	**0.0**	**100.0**	**0.01**	**100**
Coast Myall Exposed Woodland	0.2	0.0	0.0	0.0	0.0	0.2	100.0	0.0	100.0	0.0	**100**
Grassland	**934.4**	**606.7**	**64.9**	**67.3**	**72.1**	**124.8**	**85.5**	**58.1**	**91.7**	**77.7**	**100**
Disturbed Grassland	934.4	606.7	64.9	67.3	72.1	124.8	85.5	58.1	91.7	77.7	**100**
TOTAL (ha)	**2238.0**	**1100.0**		**211.7**		**408.4**		**298.7**		**219.2**	

8.5 Impact on Vegetation Communities

It is assumed for the purpose of this assessment that all vegetation within the Proposed Disturbance Area will be removed as a result of the Project. The dominant vegetation formation within the Proposed Disturbance Area is the Woodland, and there will be a gradual removal of this vegetation over each of the mine stages. Conversely, the removal of the Riparian/Floodplain formation will be more concentrated at the beginning and end of the Project, with only small amounts being removed between Year 5 and Year 15 of the mine staging. There is only 0.3 hectares of Shrubland within the Proposed Disturbance Area, and this will be removed in Year 10 of the mine staging. The majority of the Grassland formation will be removed in the first mine stage, with the gradual removal of the remaining extent over the remaining mine stages. **Table 8.1** quantifies the cumulative removal of each vegetation formation for each mine stage.

8.5.1 Communities within Woodland Vegetation Formation

Eight Woodland vegetation communities occur within the Study Area. These comprise Slaty Box Woodland, Ironbark Woodland Complex, Bulloak Woodland, Sheltered Grey Gum Woodland, Red Ash Sheltered Forest, Drooping Sheoak Woodland, Mixed Species Revegetation/Plantation and Paperbark Woodland. Of these, all communities except for the Sheltered Grey Gum Woodland, Red Ash Sheltered Forest and Mixed Species Revegetation/Plantation occur partly or wholly within the Proposed Disturbance Area. The percentage loss of the woodland vegetation formations will be quite high, with all communities except for the Drooping Sheoak and Slaty Box Woodland resulting in a 50% or greater reduction of their occurrence within the Study Area. Drooping Sheoak Woodland will be reduced by 37.3% and the Slaty Box Woodland will be reduced by 46.5% of their current occurrence.

The loss of such proportions of these vegetation communities will greatly reduce the extent of these communities within the Study Area, however is not likely to result in a significant overall reduction in woodland plant species, as large areas of the Woodland formation will be retained within the Proposed Offset Areas. This will consist of a variety of vegetation communities, thus preserving the existing variation in woodland vegetation communities in the Study Area.

Two woodland vegetation communities are represented in the Proposed Offset Areas only in very small amounts. These are the Bulloak Woodland (0.4% within Proposed Offset Areas) and the Paperbark Woodland (15.2% within Proposed Offset Areas). Paperbark Woodland should be a priority for revegetation and regeneration activities, to allow for its increased representation within the Proposed Offset Areas, and within the post-mining landscape. Bulloak Woodland is likely to re-establish unassisted as part of the Ironbark Woodland Complex, as it favours highly disturbed environments.

8.5.2 Communities within Riparian/Floodplain Vegetation Formation

Of the five Riparian/Floodplain vegetation communities occurring within the Study Area, three occur within the Proposed Disturbance Area. These comprise the Swamp Oak Riparian Forest, Rough-barked Apple Woodland and Forest Red Gum Riparian Woodland. Of these, the Swamp Oak Riparian Forest and Rough-barked Apple Woodland will be subject to only minor impacts, with the loss of 4.9% and 2.9% of their occurrence respectively. Forest Red Gum Riparian Woodland, however, is located entirely within the Proposed Disturbance Area, and thus all of this vegetation community (51 hectares) will be removed as a result of the Project. This represents not only the loss of the entire occurrence of this vegetation community within the Study Area, but also the loss of 62.9% of the overall occurrence of this vegetation formation in the Study Area.

Removal of Forest Red Gum Riparian Woodland will result in a decrease in the representation of a number of riparian plant species which are not represented elsewhere within the Study Area. This will contribute to an overall decrease in biodiversity in the Study Area as a result of the Project.

Due to the specific landscape requirements of this vegetation formation, there are limited opportunities for revegetation and regeneration of this vegetation formation within the Proposed Offset Areas and post-mining landscape. Areas which are suitable for revegetation of this vegetation formation are discussed in **Section 9**.

8.5.3 Communities within Shrubland Vegetation Formation

There are three Shrubland vegetation communities occurring within the Study Area, comprising: Tall Mixed Shrubland Complex, Weeping Myall Woodland and Coast Myall Exposed Woodland. The Coast Myall Exposed Woodland and Weeping Myall Woodland communities occur within the Proposed Disturbance Area, albeit only in very small areas (totalling 0.3 hectares). All of the Coast Myall Exposed Woodland vegetation community within the Proposed Disturbance Area will be removed as a result of the Project. The Weeping Myall Woodland falls within the centre of the proposed rail loop of the Proposed Disturbance Area, and is expected to be able to be protected. No impact is expected for the other Shrubland vegetation communities, as these occur within the Proposed Offset Areas only.

The removal of a very small area of this vegetation formation will not result in a significant reduction of biodiversity within the Shrubland formation.

8.5.4 Communities within Grassland Vegetation Formation

With only one vegetation community comprising this vegetation formation, the Project will require the removal of 51.7% of the existing Disturbed Grassland within the Study Area. The removal of over half of this vegetation community is not likely to comprise a significant loss of biodiversity, as this vegetation community is mainly the result of historical clearing for agriculture.

8.6 Impact on Fauna Habitat

Fauna habitat within the Study Area has been described and quantified on the basis of the vegetation formations, namely: Woodland, Riparian/Floodplain, Shrubland and Grassland. These vegetation formations provide differing types and levels of habitat for native fauna species, particularly a number of threatened fauna species, as previously identified. The habitat value of the vegetation formations within the Proposed Disturbance Area are identified below and an assessment of the impact of the loss of this habitat is also included. **Table 8.1** quantifies the cumulative removal of each fauna habitat formation for each mine stage.

8.6.1 Woodland Vegetation Formation

The removal of over 50% of the Woodland vegetation formation within the Study Area will represent the loss of considerable amounts of fauna habitat. The majority of this habitat will be foraging habitat in the form of canopy vegetation, tree trunks and large branches and bark subsurfaces. Associated with the extensive tree canopies of this formation are high levels of leaf litter coverage and depth, as well as fallen timber. Such features form an important foraging resource for threatened fauna species. Other habitat features such as a moderately dense mid-understorey and shrub layer provide additional resources for foraging and for nesting for some threatened woodland bird species.

This vegetation formation only recorded 1.6 hollow-bearing trees per hectare in the Proposed Disturbance Area, which is a relatively low result when considering the much higher values for the Riparian/Floodplain formation. It is notable also, that the Woodland vegetation formation of the Proposed Offset Areas recorded a much higher density than in the Proposed Disturbance Area, with 7.1 hollow-bearing trees recorded per hectare in the latter. This difference is likely to be the result of different historical disturbance regimes for the two areas, as well as chance resulting from grid-sampling methods (see **Section 4.3**). In relation to hollow size classes, the Woodland formation within the Proposed Disturbance Area recorded relatively low numbers of all hollow sizes. There were no records of very small or very large hollows. The small and large hollow classes occurred at a rate of 3.1 hollows per hectare, while the medium class scored only 1.6 hollows per hectare. These levels are relatively low, when compared to the Riparian/Floodplain formation of the Proposed Disturbance Area.

In general, this vegetation formation is most valuable in providing large amounts of foraging habitat for a number of fauna groups. The relatively low level of hollows in the vegetation formation reduces its value as roosting and nesting habitat for hollow-dependent species. This vegetation formation is likely to be most valuable to the non-hollow-dependent threatened species such as the grey-crowned babbler (*Pomatostomus temporalis temporalis*), hooded robin (*Melanodryas cucullata cucullata*) and speckled warbler (*Pyrrholaemus sagittata*). This vegetation formation would also be valuable to those hollow-dependent species that are mobile enough to travel between areas containing roosting hollows and this valuable foraging resource. Such species would include the micro-bat species eastern freetail-bat (*Mormopterus norfolkensis*), eastern false pipistrelle (*Falsistrellus tasmaniensis*) and eastern cave bat (*Vespadelus troughtoni*).

8.6.2 Riparian/Floodplain Formation

While the loss of this vegetation formation does not represent a large area of vegetation to be removed, it did record the highest levels of habitat trees per hectare (9.4), as well as high to moderate levels of very small, small, medium and large hollows. This formation thus provides the highest levels of habitat trees in the Study Area, as well as most of the highest levels of each hollow size class. This vegetation formation would be most valuable to hollow-dependent threatened species such as the squirrel glider (*Petaurus norfolcensis*), greater broad-nosed bat (*Scoteanax rueppellii*) and brown treecreeper (*Climacteris picumnus victoriae*). Thus, the major implication of the removal of the majority of this vegetation formation, will be the loss of habitat containing some of the highest hollow densities within the Study Area, which may create a considerable impact on those threatened species that are hollow-dependent.

8.6.3 Shrubland Formation

The Shrubland vegetation formation is likely to be exposed to the least impact from the Project as the majority of the Shrubland is located within the Proposed Offset Areas. With only 0.2 hectares of this vegetation formation likely to be removed, the level of habitat provision of this formation will not be significantly affected. This formation contains some mature trees, some of which contained hollows. As this vegetation formation will sustain only minor loss as a result of the Project, the habitat value of this formation to key threatened fauna species will remain essentially unchanged. This will assist in minimising the overall impact on species such as the grey-crowned babbler (*Pomatostomus temporalis temporalis*) and speckled warbler (*Pyrrholaemus sagittata*).

8.6.4 Grassland Formation

This vegetation formation is most likely to provide open foraging habitat for threatened fauna species adjoining vegetated refuge areas. It is likely that these open areas provide foraging habitat for a number of threatened fauna species, however this would be as sub-optimal, modified habitat only. Such habitat is most likely to benefit species that favour woodland margins and open areas such as the hooded robin (*Melanodryas cucullata cucullata*), as well as species that would benefit from ecotones for foraging, such as the masked owl (*Tyto novaehollandiae*) and turquoise parrot (*Neophema pulchella*). It is unlikely that this vegetation community would form the primary foraging resource for any threatened fauna species identified within the Study Area. It is also unlikely that this vegetation community would contain significant areas of specific habitat features for threatened fauna.

8.7 Impact on Aquatic Habitat and Species

The Project will result in significant alteration to aquatic habitats within the Proposed Disturbance Area. The Project will result in the removal of Clarks Gully from Year 1, and Anvil Creek from approximately Year 10. The impact on these two drainage systems occurring within the Proposed Disturbance Area, as well as the drainage systems falling within the Proposed Offset Areas, are summarised below.

8.7.1 Impact on Aquatic Flora

The Project will result in the removal of Anvil Creek and Clarks Gully from within the Proposed Disturbance Area. The aquatic vegetation in the Proposed Disturbance Area is described as being scattered and of low floristic value. The dominant aquatic species is the introduced sharp rush (*Juncus acutus* subsp*. acutus)*. The aquatic communities within the Proposed Disturbance Area are similar to other aquatic vegetation communities occurring within ephemeral drainage lines and creeks of the region and are not considered to be floristically significant.

As there is no plan to reinstate instream aquatic habitat to the reconstructed drainage channel of the post-development landscape, the Project will result in the loss of aquatic habitat within Anvil Creek and Clarks Gully. This will result in the loss of aquatic habitat within the Proposed Disturbance Area as a result of the Project.

The loss of aquatic vegetation as part of the Project is considered unlikely to be significant from a local or regional perspective, due to the occurrence of similar aquatic communities over a wide area of the upper Hunter Valley.

The drainage channel to be constructed as part of the final free-draining landform where Anvil Creek now exists will be designed and constructed to provide a stable vegetated riparian zone with a natural appearance that blends in with any adjoining riparian areas. Native trees and shrubs will be planted along the riparian zone to enhance the long term stability of the drainage system and to provide suitable habitat for native terrestrial fauna. There are currently no plans to reinstate instream aquatic habitat. This is detailed further within **Section 9** of this report.

8.7.2 Impact on Aquatic Fauna and Fauna Habitat

Natural aquatic habitats within the Proposed Disturbance Area are highly ephemeral systems with aquatic fauna communities dominated by species with high pollution tolerances. The aquatic fauna habitat value of Anvil Creek and Clarks Gully offers poor quality habitat for native fish and macroinvertebrate species. Aquatic fauna communities and habitats identified within the Proposed Disturbance Area are similar to other communities and habitats in the region, and the habitats are not considered to be regionally significant.

As there is no plan to reinstate instream aquatic habitat to the drainage channels of the post-development landscape, the Project will result in the loss of aquatic habitat within Anvil Creek and Clarks Gully, resulting in the loss of aquatic habitat within the Proposed Disturbance Area as a result of the Project.

The loss of aquatic fauna habitat as part of the Project is considered unlikely to be significant from a local or regional perspective, due to the occurrence of the identified species and habitats over a wide area in the upper Hunter Valley.

The Project will not result in the introduction of fish to freshwaters within a river catchment outside their natural range, however it will result in the removal of large woody debris wherever it occurs within Anvil Creek and Clarks Gully.

The Project will result in changes in the flow regime within Big Flat Creek as the mine water management system is developed and mining progresses. This will result in reduced annual flow volumes in the creek. The frequency and duration of flows within the creek system is not expected to be significantly changed by the Project, however the magnitude of these flows will change. It is considered that sufficient flow volumes will be maintained in the creek system to fill the pools and holes along Big Flat Creek that sustain the current aquatic and riparian habitat characteristics of the creek system.

The Project is unlikely to adversely impact on channel stability or instream habitat of the Big Flat Creek, Wybong Creek or Sandy Creek systems.

8.8 Environmental Planning and Assessment Act 1979

The commencement of the Part 3A (Major Projects) provisions of the *Environmental Planning and Assessment Act* 1979 (EP&A Act 1979) on 1 August 2005 meant that the use of the ‘Eight Part Test’ or the recently gazetted “Assessment of Significance” for assessing the level of potential impacts on threatened species is not relevant to a State Significant project such as the Anvil Hill Project.

The “Assessment of Significance” recently replaced the “Eight Part Test” as the means of determining the level of impact on threatened species, however no specific criteria were established for the assessment during the development of this report.

Consequently, consideration was given as to what type of assessment would be necessary to adequately assess the likely significance of impacts on threatened species for the Anvil Hill Project. The “Eight Part Test” had already established a benchmark that was well recognised by consultant ecologists and authority assessment officers.

As a result of consultation with DoP and DEC, the key components of the “Eight Part Test” were retained for this assessment with their structure modified to minimise repetition and to allow for relevant entities to be assessed together.

To achieve this, the “Test of Ecological Significance” used for this Project is divided into the following five key components, each with its own specific questions:

- threatened species;
- endangered populations;

- endangered ecological communities;
- key threatening processes; and
- critical habitat.

A "Test for Ecological Significance" was used to assess the likely impacts on those threatened species, endangered populations and endangered ecological communities that were recorded within the Study Area, as well as for those species with potential habitat within the Study Area (refer to **Sections 8.8.1** and **8.8.2**). These assessments are provided in full in **Appendix F**.

8.8.1 Potential Threatened Flora Species, Populations and Endangered Ecological Communities

The Test for Ecological Significance was completed for the following threatened flora species, endangered populations and endangered ecological communities, either due to their recorded presence within the Study Area, or due to the presence of potential habitat within the Study Area.

8.8.1.1 Potential Threatened Flora Species

- *Commersonia rosea;*
- *Cynanchum elegans;*
- *Diuris pedunculata;*
- painted diuris (*Diuris tricolor*)*;*
- narrow goodenia (*Goodenia macbarronii*)*;*
- *Isotropis foliosa;*
- *Kennedia retrorsa;*
- *Lasiopetalum longistamineum;*
- *Philotheca ericifolia;*
- *Pomaderris bodalla;*
- *Pomaderris queenslandica;*
- *Pomaderris reperta;*
- *Prostanthera cineolifera;*
- *Prostanthera cryptandroides;*
- *Prostanthera discolor*; and
- austral toadflax (*Thesium australe*)*.*

8.8.1.2 Potential Endangered Flora Populations

- *Acacia pendula* population in the Hunter Catchment;
- *Cymbidium canaliculatum* population in the Hunter Catchment; and
- *Eucalyptus camaldulensis* population in the Hunter Catchment.

8.8.1.3 Potential Endangered Ecological Communities

- Weeping Myall Woodland EEC.

A total of six plant species, two endangered plant populations (one of those a preliminary listing), and one endangered ecological community listed under the TSC Act 1995 have been recorded in the Study Area. Of these, three plant species are also listed as threatened under the EPBC Act 1999, and two further species under consideration for listing, were recorded within the Study Area (refer to **Section 8.6.3**), as well as one ROTAP species (refer to **Section 4.4**). Two of the aforementioned species are ROTAPS, while one further ROTAP not listed under the TSC Act 1995 or EPBC Act 1999 is present. **Table 4.7** identifies those threatened flora species, endangered populations and endangered ecological communities that have been recorded in the Proposed Disturbance Area. These species will be impacted by the Project, as it is expected that all vegetation within the Proposed Disturbance Area will be removed, or directly impacted in some way. The one exception to this is the occurrence of the EEC Weeping Myall Woodland (also considered to be the *Acacia pendula* Endangered Population) within the centre of the proposed rail loop in the Proposed Disturbance Area. This vegetation community is expected to be able to be retained and protected within the centre of the rail loop.

A number of other plant species that could occur in the Proposed Disturbance Area, but were not detected, could be impacted by the Project (refer to **Table 4.6**).

From these, and based on the Test for Ecological Significance, it is considered that the Project is likely to have a significant impact on narrow goodenia (*Goodenia macbarronii*) and may have a significant impact on painted diuris (*Diuris tricolor*). The remaining plant species, endangered populations and endangered ecological community are not expected to be significantly impacted by the Project in any direct manner, as they are not considered likely to occur in the Proposed Disturbance Area or, if likely to be present, will only be impacted to a lesser level.

The dominant cause of the significant impact on these two flora species arises from the loss of known occurrences of narrow goodenia within the Proposed Disturbance Area, and of large areas of predicted habitat for both narrow goodenia and painted diuris. It is expected that all of the recorded occurrences of this latter species within the Study Area will be removed as a result of the Project. There is the potential for additional records of narrow goodenia to occur within a number of the vegetation communities within the Study Area. Predicted habitat for painted diuris occurs throughout the extensive areas of Disturbed Grassland within the Proposed Disturbance Area. The only known record of painted diuris within the Study Area comes from the Proposed Offset Areas, and will not be disturbed as a result of the Project.

The records of narrow goodenia from the Proposed Disturbance Area add to the small number of records for this species in the Hunter Valley. The records of this species within the Proposed Disturbance Area represent the largest area of known habitat for this species within the Hunter Region. Most of this known habitat will be lost as a result of the Project. It is likely that these records represent an important population of this species within the Study Area. The loss of this population is likely to increase fragmentation of the population within the vicinity of the Study Area considerably, and the isolation of small sub-populations of this species may impact on genetic flow and greatly increase the potential for local extinctions of this species.

8.8.2 Threatened Fauna Species

The Test for Ecological Significance was completed for the following threatened fauna species, either due to their recorded presence within the Study Area, or due to the presence of potential habitat within the Study Area.

8.8.2.1 Potential Threatened Amphibians

- green and golden bell frog (*Litoria aurea*).

8.8.2.2 Potential Threatened Reptiles

- pink-tailed legless lizard (*Aprasia parapulchella*);
- Rosenberg's goanna (*Varanus rosenbergi*);
- pale-headed snake (*Hoplocephalus bitorquatus*); and
- broad-headed snake (*Hoplocephalus bungaroides*).

8.8.2.3 Potential Threatened Birds

- square-tailed kite (*Lophoictinia isura*);
- osprey (*Pandion haliaetus*);
- red goshawk (*Erythrotriorchis radiatus*);
- grey falcon (*Falco hypoleucos*);
- red-backed button-quail (*Turnix maculosa*);
- bush stone-curlew (*Burhinus grallarius*);
- gang-gang cockatoo (*Callocephalon fimbriatum*);
- red-tailed black-cockatoo (*Calyptorhynchus banksii*);
- glossy black-cockatoo (*Calyptorhynchus lathami*);
- superb parrot (*Polytelis swainsonii*);
- swift parrot (*Lathamus discolor*);
- turquoise parrot (*Neophema pulchella*);
- powerful owl (*Ninox strenua*);
- barking owl (*Ninox connivens*);
- sooty owl (*Tyto tenebricosa*);

- masked owl (*Tyto novaehollandiae*);
- brown treecreeper (*Climacteris picumnus victoriae*);
- regent honeyeater (*Xanthomyza phrygia*);
- black-chinned honeyeater (*Melithreptus gularis gularis*);
- painted honeyeater (*Grantiella picta*);
- speckled warbler (*Pyrrholaemus sagittata*);
- hooded robin (*Melanodryas cucullata cucullata*);
- grey-crowned babbler (*Pomatostomus temporalis temporalis*);
- olive whistler (*Pachycephala olivacea*); and
- diamond firetail (*Stagonopleura guttata*).

8.8.2.4 Potential Threatened Mammals

- spotted-tailed quoll (*Dasyurus maculatus maculatus*);
- brush-tailed phascogale (*Phascogale tapoatafa tapoatafa*);
- common planigale (*Planigale maculata*);
- koala (*Phascolarctos cinereus*);
- eastern pygmy possum (*Cercartetus nanus*);
- squirrel glider (*Petaurus norfolcensis*);
- brush-tailed rock-wallaby (*Petrogale penicillata*);
- grey-headed flying-fox (*Pteropus poliocephalus*);
- yellow-bellied sheathtail bat (*Saccolaimus flaviventris*);
- eastern freetail-bat (*Mormopterus norfolkensis*);
- eastern bentwing-bat (*Miniopterus schreibersii oceanensis*);
- greater long-eared bat (*Nyctophilus timoriensis*);
- little pied bat (*Chalinolobus picatus*);
- eastern false pipistrelle (*Falsistrellis tasmaniensis*);
- large-eared pied bat (*Chalinolobus dwyeri*);
- large-footed myotis (*Myotis adversus*);

- greater broad-nosed bat (*Scoteanax rueppellii*); and
- eastern cave bat (*Vespadelus troughtoni*).

A total of 19 fauna species listed as threatened under the TSC Act 1995 have been recorded in the Study Area. This number includes two species also listed as Vulnerable under the EPBC Act 1999. In addition to this, four migratory species listed under the EPBC Act 1999 were recorded within the Study Area. These EPBC Act 1999 listed species are addressed further in **Section 8.10**. **Table 5.2** identifies those threatened fauna species and EPBC listed migratory species that were recorded in the Proposed Disturbance Area. These species will be impacted by the Project, as it is expected that all habitat for these species within the Proposed Disturbance Area will be removed, or directly impacted in some way.

A number of other fauna species that could occur in the Proposed Disturbance Area, but were not detected, could be impacted by the Project (**Table 5.1**).

From these, and based on the Test for Ecological Significance, it is considered that the Project is likely to or may have a significant impact on the following key threatened fauna species:

- brown treecreeper;
- speckled warbler;
- hooded robin;
- grey-crowned babbler;
- diamond firetail;
- squirrel glider;
- eastern freetail-bat;
- eastern bentwing-bat;
- eastern false pipistrelle;
- large-eared pied bat;
- large-footed myotis;
- greater broad-nosed bat; and
- eastern cave bat.

The remaining fauna species are not expected to be significantly impacted by the Project in any direct manner, as they are not considered likely to occur in the Proposed Disturbance Area or, if likely to be present, will only be impacted to a lesser level.

The major cause of these significant impacts on threatened species within the Study Area is the loss of a large amount of tree-dominated vegetation (1304 hectares) within the Proposed Disturbance Area. This loss of vegetation is likely to affect different threatened species in different ways, with the majority of the impact coming from the loss of general foraging habitat. As a number of records were obtained for most threatened species within the Study Area, it is likely that there is intra-specific, as well as inter-specific competition occurring for general foraging habitat, as well as for specific habitat resources. With the loss of habitat from the Proposed Disturbance Area, it is likely that such competition will be increased considerably within the Proposed Offset Areas, due to dispersing individuals.

Competition for resources may have a major impact on those species forced to move into the Proposed Offset Areas in front of the advancing mine. As many of the key threatened species recorded in the Study Area are known to be territorial, significant pressure may be placed on dispersing individuals to compete for, establish and defend an area of habitat that is large enough, and of sufficient quality to allow survival. Those displaced individuals from the Proposed Disturbance Area may face significant challenges to establish new territories, particularly if that area is already fully occupied by other sub-populations of its species. For example, hooded robins moving out of the Proposed Disturbance Area may face considerable difficulty in establishing territories within the Proposed Offset Areas, as sub-populations of this species are already present and are likely to be actively defending their territories from intruders. Particular threats from such competition could include injury or death from territorial disputes, increased disease from overcrowding, increased competition for resources, increased competition for mates, increased risk of starvation or increased chance of predation.

Where territorial species are also competing for limiting habitat resources, this can greatly increase competitive stresses on dispersing individuals. The brown treecreeper is a territorial species that also requires small hollows (a limited habitat resource) for breeding. Establishing a new territory containing sufficient foraging habitat, as well as a number of suitable hollows for breeding, is likely to be difficult for dispersing brown treecreepers, particularly when this species already occurs within the Proposed Offset Areas.

The loss of habitat within the Proposed Disturbance Area will force some species to attempt to disperse through sub-optimal habitat. This habitat may be sub-optimal for any number of reasons, for example it may not contain suitable habitat features such as hollows, dense groundcover and shrub layers for protection; suitable fallen timber and ground features for terrestrial dispersal; or the vegetation may not be mature enough to offer adequate protection from predators. Many of the key threatened species are typically unable to travel well through sub-optimal habitat. The grey-crowned babbler, for example, is known to be unable to travel through extensively fragmented landscapes. This species requires continuous protective vegetation cover, particularly shrub species, to disperse through a landscape. Similarly, the squirrel glider requires an adequate density of trees and tall shrubs to allow it to disperse through the canopy. When forced to disperse along the ground, this species is particularly prone to predation.

Some impacts may not operate directly on threatened fauna species, however may manifest through impacts on prey species. The loss of habitat within the Proposed Disturbance Area may not directly impact on the three threatened owl species recorded from within (or near to) the Study Area, however these impacts would be most heavily demonstrated in their prey species. These owls are mobile enough to travel to larger vegetated areas in search of foraging and nesting habitat, however the small to medium mammal species that form their core diet within the Study Area would be unable to do so. This is likely to have a flow-on impact on the threatened owl species of the region. In addition to this, many of the core prey species of these owls are hollow-dependent, thus limiting habitat features may impact on their numbers. As the Study Area is known to support a number of owl species (including threatened species), any decrease in the diversity and abundance of small to medium mammal species could result in a reduction in owl numbers and diversity in the Study Area.

8.8.3 Critical Habitat

There are currently two listings and two recommended listings on the Critical Habitat Register, these being:

- *Bomaderry zieria* within the Bomaderry bushland - critical habitat recommendation;
- *Wollemia nobilis* (the Wollemi pine) - critical habitat recommendation;
- Little penguin population in Sydney's North Harbour - critical habitat declaration; and
- Mitchell's Rainforest Snail in Stotts Island Nature Reserve - critical habitat declaration.

While parts of the northern borders of Wollemi National Park lie approximately 20 kilometres to the south of the Study Area, the Project will not impact on the areas recommended for declaration as critical habitat for the Wollemi Pine (*Wollemia nobilis*).

The Project will not impact on any other areas of declared critical habitat.

8.8.4 Key Threatening Processes

There are currently 30 key threatening processes (KTPs) (including those pending finalisation) listed under the schedules of the TSC Act 1995. Of these, a number have been discounted from this assessment, due to their irrelevance to the Study Area, and the Project. The remaining KTPs are discussed in detail within the Test of Ecological Significance (**Appendix F**).

In general, the Project is likely to cause an increase in the incidence of the following KTPs within the Study Area:

- Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands;
- Bushrock removal;
- Clearing of native vegetation; and
- Removal of dead wood and dead trees.

8.8.5 SEPP 44 Assessment

The Project is subject to assessment under State Environmental Planning Policy (SEPP) No. 44 (Koala Habitat Protection) as it lies in a local government area listed in Schedule 1 of the policy. SEPP 44 aims to encourage the proper conservation and management of areas of natural vegetation that provide habitat for the koala (*Phascolarctos cinereus*), to ensure permanent free-living populations over their present range and to reverse the current trend of population decline. Any development application in an identified local government area, affecting an area of one hectare or greater, must be assessed under the policy.

The SEPP 44 assessment completed as part of the survey initially consisted of the assessment of potential koala habitat by determining the proportion of Schedule 2 feed tree species (**Section 3.3.3.4**). Of the 158 sites surveyed, 6 were identified as potential koala habitat. Of these, one was located within the Proposed Disturbance Area, with the others located within the Proposed Offset Areas.

The identification of potential koala habitat required additional surveys for signs of koala presence, including scat searches, spotlighting, visual canopy searches, as well as diurnal and nocturnal call playback. These additional searches were completed to determine the likelihood of core koala habitat being present within the Study Area. No signs of koala presence were identified from these surveys.

However, a small number of koala scats were collected from underneath a single tree during opportunistic surveys. This tree was located within the Proposed Offset Areas (**Figure 5.1**). This was the only koala scat site identified in the Study Area, despite a significant level of survey effort. The failure to find koalas or more koala scats suggests that the Proposed Offset Areas is of very marginal habitat quality for the koala and is most likely only used by dispersing individuals or sub-dominant animals at very low density. Therefore it is unlikely that the Proposed Offset Areas provides core koala habitat, as determined by the presence of breeding females.

No koalas or koala scats were identified in any part of the Proposed Disturbance Area despite a significant level of survey effort. Therefore no koala core habitat was identified in the Proposed Disturbance Area. As a result, the Proposed Disturbance Area is not considered to provide any koala habitat.

As a result of the above assessment, SEPP 44 does not place any constraints on the Project.

8.9 Fisheries Management Act 1994

The threatened species schedules of the Fisheries Management Act 1994 comprise lists of endangered species, populations and ecological communities and species presumed extinct, vulnerable species, and key threatening processes. These schedules indicate that the Hunter River drainage basin is outside the known distribution of species, populations and ecological communities listed under this legislation. Therefore none of the listed species, populations and ecological communities are expected to occur in the Study Area, and none would be impacted by the Project.

8.9.1 Impact on Threatened Aquatic Species

As discussed in **Section 8.9,** no threatened aquatic species are known to occur within the Hunter Catchment. The Project will have no impact on threatened aquatic species.

8.9.2 Key Threatening Processes

Key Threatening Processes (KTPs) currently listed under the Fisheries Management Act 1994 with the potential to be relevant to this Project are listed below. With each, an assessment of the applicability of the threatening process to the Project is provided.

- **The removal of large woody debris:** The removal of Anvil Creek and Clarks Gully is likely to require the removal of any large woody debris within these creeks. The Project is likely to represent this Key Threatening Process.

- **The degradation of native riparian vegetation along NSW water courses:** The Project will require works within riparian habitats. The entire occurrence of the Forest Red Gum Riparian Woodland within the Study Area will require removal, as will approximately 5% of the Swamp Oak Riparian Forest and approximately 3% of the Rough-barked Apple Woodland within the Study Area. As a result of this, it is likely that the Project represents this Key Threatening Process. Despite this, the revegetation of the Proposed

Disturbance Area, as well as the riparian zones of the post-mining drainage channels is likely to ameliorate the impact of this KTP.

- **The installation and operation of in-stream structures and other mechanisms that alter natural flow regimes of rivers and streams:** Anvil Creek will be removed as mining progresses between Years 10 to 20 of the Project. Prior to mining at Year 10, a levee will be constructed to prevent back flows from Big Flat Creek from entering the Proposed Disturbance Area. Clarks Gully will be removed as mining progresses between Years 0 and 6. Catchment flows will be captured for reuse on site during the mining operation. Big Flat Creek will not be directly impact by the Project, however peak flows within the creek are expected to be lessened slightly. These works will represent this KTP. The creation of a number of drainage channels within the post-mining landscape will allow for the creation of a free draining landscape, and is likely to reduce the impact of this KTP within the Study Area.

8.10 Environment Protection and Biodiversity Conservation Act 1999

Under the Commonwealth EPBC Act 1999, approval of the Commonwealth Minister for the Environment is required for any action that may have a significant impact on matters of national environmental significance (NES). These matters are:

- Listed threatened species and communities;
- Migratory species protected under international agreements;
- Ramsar wetlands of international importance;
- The Commonwealth marine environment;
- World Heritage properties;
- National Heritage places; and
- Nuclear actions.

A search of the DEH Protected Matters Search Tool (16 January 2006) identified (discounting fishes and marine species) one threatened ecological community, 26 threatened species, eight migratory species (terrestrial) and two migratory wetland species considered likely to occur, on the basis of habitat modelling, within a 20 kilometre radius of the Study Area (refer to **Appendix A**). Those species and ecological communities with potential habitat on the Study Area are shown in **Table 8.2** below. Threatened flora and fauna species with potential to occur are listed in **Tables 4.6** and **5.1** respectively. No invertebrate species were listed on the EPBC Protected Matters database within a 20 kilometre radius.

Table 8.2 - Species listed under the EPBC Act 1999 with Potential Habitat in the Study Area

Common Name	Scientific Name	Classification	Potential to Occur
broad-headed snake	*Hoplocephalus bungaroides*	Threatened Species	Yes
malleefowl	*Leipoa ocellata*	Threatened Species Migratory Terrestrial Species	No
Australian painted snipe	*Rostratula benghalensis australis*	Threatened Species	No
superb parrot	*Polytelis swainsonii*	Threatened Species	Yes
swift parrot	*Lathamus discolor*	Threatened Species Listed Marine Species	Yes
regent honeyeater	*Xanthomyza phrygia*	Threatened Species Migratory Terrestrial Species	Yes
spotted-tailed quoll (SE mainland)	*Dasyurus maculatus maculatus*	Threatened Species	Yes
brush-tailed rock-wallaby	*Petrogale penicillata*	Threatened Species	Yes
grey-headed flying-fox	*Pteropus poliocephalus*	Threatened Species	Yes
greater long-eared bat	*Nyctophilus timoriensis*	Threatened Species	Yes
large-eared pied bat	*Chalinolobus dwyeri*	Threatened Species	Yes
rainbow bee-eater	*Merops ornatus*	Listed Marine Species	Yes
cattle egret	*Ardea ibis*	Listed Marine Species	Yes
great egret	*Ardea alba*	Listed Marine Species	Yes
white-bellied sea-eagle	*Haliaeetus leucogaster*	Migratory Terrestrial Species Listed Marine Species	Yes
white-throated needletail	*Hirundapus caudacutus*	Migratory Terrestrial Species Listed Marine Species	Yes
black-faced monarch	*Monarcha melanopsis*	Migratory Terrestrial Species Listed Marine Species	Yes
satin flycatcher	*Myiagra cyanoleuca*	Migratory Terrestrial Species Listed Marine Species	Yes
Japanese snipe	*Gallinago hardwickii*	Migratory Wetland Species Listed Marine Species	No
painted snipe	*Rostratula benghalensis s. lat.*	Migratory Wetland Species Listed Marine Species	No
fork-tailed swift	*Apus pacificus*	Listed Marine Species	Yes
white-flowered wax plant	*Cynanchum elegans*	Threatened Species	Yes
finger panic grass	*Digitaria porrecta*	Threatened Species	No
painted diuris	*Diuris tricolor*	Threatened Species	Yes
narrow goodenia	*Goodenia macbarronii*	Threatened Species	Yes
	Homoranthus darwinioides	Threatened Species	No
	Kennedia retrorsa	Threatened Species	Yes
	Lasiopetalum longistamineum	Threatened Species	Yes
	Ozothamnus tessellatus	Threatened Species	Yes
rufous pomaderris	*Pomaderris brunnea*	Threatened Species	No
	Prostanthera cryptandroides	Threatened Species	Yes
	Rulingia procumbens	Threatened Species	Yes
austral toadflax	*Thesium australe*	Threatened Species	Yes
Wollemi pine	*Wollemia nobilis*	Threatened Species	No
	White Box – Yellow Box – Blakely's Red Gum Grassy Woodlands and Derived Native Grasslands	Threatened Ecological Community	No

The EPBC Act 1999 lists criteria which are used to determine whether an action is likely to have a significant impact on matters of NES. These criteria are addressed in the Assessment of Significance provided in **Appendix G**.

Extensive seasonal surveys of the Study Area identified the presence of a number of species listed under the EPBC Act 1999. A number of additional species are considered to have the potential to occur within the Study Area, however were not identified.

The Project is not considered likely to cause a significant impact on the endangered swift parrot (*Lathamus discolor*), regent honeyeater (*Xanthomyza phrygia*), spotted-tailed quoll (*Dasyurus maculatus maculatus*) or *Cynanchum elegans.*

The vulnerable brush-tailed rock-wallaby (*Petrogale penicillata*), large-eared pied bat (*Chalinolobus dwyeri*), lobed bluegrass (*Bothriochloa biloba*), painted diuris (*Diuris tricolor*), narrow goodenia (*Goodenia macbarronii*) and *Lasiopetalum longistamineum* were recorded within the Study Area during surveys. It is not considered that the Study Area contains habitat for an important population of the brush-tailed rock-wallaby, large-eared pied bat, lobed bluegrass of *Lasiopetalum longistamineum*. However, it is likely that important populations of painted diuris and narrow goodenia are present within the Study Area. It is possible or likely that the Project will lead to a significant impact on important populations of painted diuris and narrow goodenia.

The migratory species rainbow bee-eater (*Merops ornatus*), white-bellied sea-eagle (*Haliaeetus leucogaster*), white-throated needletail (*Hirundapus caudacutus*) and satin flycatcher (*Myiagra cyanoleuca*) were recorded within the Study Area. It is not considered that the Study Area provides important habitat or an ecologically significant proportion of the entire populations for the rainbow bee-eater, white-bellied sea-eagle, white-throated needletail and satin flycatcher. The Project is unlikely to result in a significant impact on identified or potential migratory species within the Study Area.

It is considered that the Project is likely to have a significant impact on narrow goodenia (*Goodenia macbarronii*) and may have a significant impact on painted diuris (*Diuris tricolor*). While it is likely that this significant impact could be successfully ameliorated through the detailed Biodiversity Offset Strategy (refer to **Section 9**), a Preliminary Referral will be made to the Minister for the Environment in relation to this Project.

8.11 Summary of Pre-Mitigation Impact

From the above sections, it is clear that the impact of the Project on the ecological features of the Study Area will result mainly from the loss of approximately 1304 hectares of treed habitat, as well as approximately 934 hectares of Disturbed Grassland within the Proposed Disturbance Area. The vegetation contained within the Proposed Disturbance Area is known habitat for at least four threatened flora species and at least 13 threatened fauna species. It is considered that those threatened flora species recorded only from the Proposed Offset Areas will not be impacted by the Project. A further six threatened fauna species recorded only from the Proposed Offset Areas also have the potential to be significantly impacted by the Project.

The loss of habitat within the Proposed Disturbance Area may or will result in a significant impact on two threatened flora species, as well as 14 threatened fauna species, consisting of five woodland birds, one terrestrial mammal, one arboreal mammal and seven micro-bats. As required with impact assessments of this kind, the detailed mitigation strategy that has been developed as part of this Project has not been included in this determination of the level of ecological impact. Rather, the current Section has identified the ecological impacts expected to result from this Project, without consideration of the potential positive ecological outcomes of the mitigation strategy.

Progressive modifications to the initial Project design have resulted in a reduced ecological impact due to the exclusion of a number of significant ecological features from the Proposed Disturbance Area. Despite these modifications, the overall impact assessment has identified a significant impact on a number of threatened species, mainly as a result of the loss of a large amount of known habitat. As this initial result does not achieve the overall goal of no net loss of flora and fauna values in the Study Area in the medium to long term, a detailed mitigation strategy has been developed, as outlined in **Section 9**.

This mitigation strategy has been developed progressively throughout the planning for this Project, with the intent of addressing and mitigating the impacts of the Project (as described within this Section). In doing so, the objective of the mitigation strategy has been to address this identified initial impact on key threatened species in order to reduce the impact as much as possible. In order to do this effectively, the overall goal is to achieve no net loss of flora and fauna values in the area in the medium to long term. **Section 9** of this report provides details on the mitigation strategy developed in order to achieve this goal.

9.0 Impact Mitigation

9.1 Background

This Section describes the detailed mitigation strategy developed as part of the Project to address and mitigate the impacts of the Project, as described in **Section 8**. This mitigation strategy has been developed progressively to address the identified potential impact on key threatened species in order to reduce this impact as much as possible, seeking to achieve the overall goal of no net loss of flora and fauna values in the area in the medium to long term.

This section addresses two types of impact mitigation strategies: those standard impact mitigation strategies that are commonly included within projects of this type and magnitude; and a Biodiversity Offset Strategy to supplement the Standard Impact Mitigation Strategy and further address impacts and reduce the overall impact on the ecological features of the Study Area.

In this case, the Standard Impact Mitigation Strategy includes the rehabilitation, revegetation and regeneration of the post-mining landscape, as well as general management strategies for fencing, weed control, feral animal control and bushfire. This strategy also includes a detailed Tree Felling Procedure to minimise impacts on fauna species during the construction phase of the Project. The management of aquatic habitat will also be addressed as part of this strategy.

The Biodiversity Offset Strategy consists of a number of additional mitigation strategies designed to address the pre-mitigation impact on key threatened species, as identified in **Section 8.11**. These measures include:

- Immediate establishment and protection of the Proposed Offset Areas to allow for the conservation of large areas of existing vegetation within the Study Area;
- Conceptual Corridor Strategy, including augmentation of existing corridor vegetation to improve existing corridor function;
- Augmentation of existing vegetation to increase habitat quality, including provision of nest boxes, fallen timber and specific foraging features for target key threatened species; and
- Development of a detailed Ecological Monitoring Program for the life of the mine, as discussed in **Section 10.1**.

The Biodiversity Offset Strategy is discussed in detail in **Sections 9.4** and **9.5**.

An Ecological Management Plan will be prepared (as part of the site Environmental Management Strategy or System) in order to provide further detail and information regarding the ongoing management and conservation of ecological features (particularly key threatened species) during the construction phase of the mine, the ongoing operation, and the post-mining landscape.

9.2 Impacts to be Offset

The discussion within **Sections 8.8** and **8.10** of this report identified a number of impacts that will or are likely to occur as a result of the Project. In particular, these sections identified key threatened species that will or may be significantly impacted by the Project. These species comprise:

- painted diuris (Diuris tricolor);
- narrow goodenia (Goodenia macbarronii);
- brown treecreeper (Climacteris picumnus victoriae);
- speckled warbler (Pyrrholaemus sagittata);
- hooded robin (Melanodryas cucullata cucullata);
- grey-crowned babbler (Pomatostomus temporalis temporalis);
- diamond firetail (Stagonopleura guttata);
- squirrel glider (Petaurus norfolcensis);
- eastern freetail-bat (Mormopterus norfolkensis);
- eastern bentwing-bat (Miniopterus schreibersii oceanensis);
- eastern false pipistrelle (Falsistrellus tasmaniensis);
- large-eared pied bat (Chalinolobus dwyeri);
- large-footed myotis (Myotis adversus);
- greater broad-nosed bat (Scoteanax rueppellii); and
- eastern cave bat (Vespadelus troughtoni).

The determination of a likely or certain significant impact on these species was made without consideration of any mitigation strategies.

Despite the identification of a potential or likely significant impact on these species, there are substantial opportunities to reduce the severity of these impacts, thus helping to mitigate impacts. The Biodiversity Offset Strategy has been developed to reduce the severity of the predicted impacts on key threatened species within the Study Area such that the level of impact over time will be negligible or indeed positive.

The Biodiversity Offset Strategy consists of a number of components that collectively aim to:

- replace habitat removed from the Proposed Disturbance Area;
- increase the quality of habitat within the Proposed Offset Areas; and
- provide access/egress into and out of the Study Area.

These components include revegetation/regeneration of the post-mining area and other areas of existing vegetation; establishment of corridors within and outside of the Study Area; augmentation of existing habitat (including nest boxes, salvage of habitat features such as hollows, boulders and fallen timber); and impact softening strategies such as ecologically designed tree clearing procedures.

While each of these methods has its own individual focus, all will contribute to providing suitable habitat for key threatened species. The components are all inter-dependent and the benefits of all will combine to produce an overall mitigation of the identified ecological impacts of this Project.

9.3 Identification of Methods to Minimise Impacts

In order to address the overall goal of no net loss of flora and fauna values in the Study Area in the medium to long term, detailed impact mitigation strategies have been developed to minimise the overall impact of the Project on threatened species, endangered populations, endangered ecological communities, or their habitats.

These impact mitigation strategies have been designed to mitigate the primary impacts of general habitat loss, as well as indirect impacts such as fragmentation, isolation and increased competition for resources. While the impact mitigation strategies are discussed individually in this chapter, they will operate in combination to reduce the overall impacts of the Project on ecological matters.

A number of actions are included within the Project to address such impacts. These actions include:

- Progressive modifications adopted in the Project design in order to avoid or reduce impacts on specific ecological features of the Study Area, such as Anvil Hill, Wallaby Rocks and Big Flat Creek (refer to **Section 8.2**);
- The use of progressive clearing approaches to reduce the area of impact as much as possible at any one time. This will result in clearing progressively as necessary in advance of operations. A detailed Tree Felling Strategy has been developed (summarised in **Section 9.4.3**), and will be provided in detail in the Ecological Management Plan;
- Immediate protection and enhancement of representative adjoining areas in Proposed Offset Areas (**Section 9.5.2**);
- Establishment of a conceptual corridor strategy within and outside of the Study Area (**Section 9.5.4**); and
- Development of an integrated catchment-approach to local and regional land use management and activities (**Section 9.5.5**).

9.4 Biodiversity Management of Mining Operations (Standard Impact Mitigation Strategies)

9.4.1 Post-mining Revegetation and Regeneration

The primary objective of mine revegetation and regeneration will be to create a stable final landform with acceptable post-mining land use capability. Revegetation and regeneration of the overburden emplacement areas and backfilled pits will be conducted progressively over the life of the mine, as an integral component of mining operations. All revegetation and regeneration works will be scheduled to commence as soon as practicable after mining disturbance. This approach will minimise the disturbed area at any point in time and hence reduce the ecological impact of the Project.

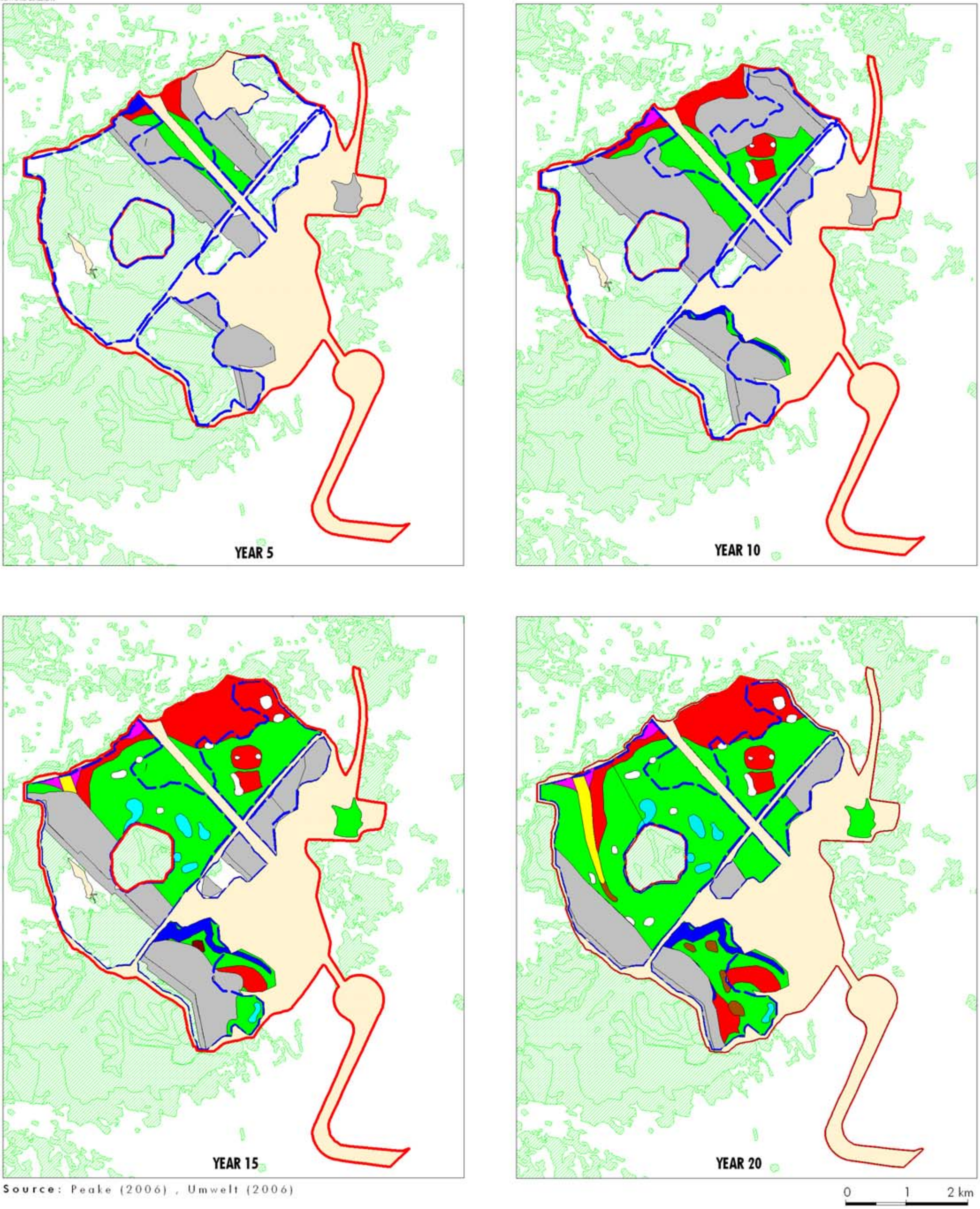
The majority of the Proposed Disturbance Area, including the open cut mining areas and overburden emplacement areas, will be progressively revegetated and regenerated to self-sustaining indigenous vegetation communities. The proposed final land use aims to emulate the pre-mining environment and will enhance local and regional ecological linkages across the Study Area and with proximate areas. Revegetation works will use local provenance species.

Moreover, the reinstatement of the majority of the Proposed Disturbance Area to self-sustaining vegetation communities will provide for a sustainable final land use option, given the inherently low land capability of the existing land (Class VI) across the majority of the Proposed Disturbance Area. Land within the eastern extent of the Proposed Disturbance Area (which contains the mine infrastructure, product handling and rail load out facilities), is proposed to be predominantly rehabilitated to agricultural land with a land capability consistent with that which currently exists. The conceptual final revegetation strategy is depicted in **Figure 9.1.**

In this case, revegetation refers to the use of methods such as planting of tubestock and direct seeding to return native vegetation to a particular area. Alternatively, the term regeneration is used to identify areas where vegetation will be allowed to return naturally to a particular area, generally by removing existing impacts such as grazing and physical disturbances such as slashing or soil compaction.

The progressive revegetation and regeneration of previously mined areas within the Proposed Disturbance Area will be a major component of the overall mine plan. In order to achieve a stable final landform consisting of self-sustaining indigenous vegetation communities, a detailed revegetation and regeneration strategy has been developed.

Revegetation of the post-mining areas of the Proposed Disturbance Area will be completed as soon as reformed areas become available for revegetation, and will include the re-establishment of a range of native vegetation communities. The proposed final revegetation plan for the post-mining areas (**Figure 9.1**) identifies the final conceptual composition of the post-mining vegetation communities, as well as the progressive rehabilitation that will be completed per mine stage. This plan provides a suitable degree of heterogeneity within the vegetation of the post-mining landscape, thus allowing for the re-establishment of a variety of vegetation types and formations (**Table 9.1**). This approach will greatly increase the value of this revegetation for fauna species, particularly key threatened species.



Source: Peake (2006), Umwelt (2006)

Legend

- Proposed Disturbance Area
- Proposed Mining Areas
- Existing Treed Vegetation
- Active Mining
- Infrastructure / Other Disturbance

- Slaty Box Woodland
- Ironbark Woodland Complex
- Sheltered Grey Gum Woodland
- Rough-barked Apple Woodland
- Forest Redgum Riparian Woodland
- Drooping Sheoak Woodland
- Paperbark Woodland
- Grassland

FIGURE 9.1

Staged Rehabilitation Strategy for Post-mining Areas

Table 9.1 – Indicative composition by Vegetation Community of Final Revegetation of Mined Areas and comparison against Pre-mining Areas

Community Name	Formation	Indicative Amount to be Cleared over mine life (ha)	Cumulative Area of Rehabilitation Available per Mine Stage (ha)				Total Area to be Revegetated (ha)	Net Change in Post-Revegetation Extent (ha)
			Year 5	**Year 10**	**Year 15**	**Year 20**		
Slaty Box Woodland	Woodland	245	20	80	214	253	309	+64
Ironbark Woodland Complex	Woodland	886	67	183	524	826	1526	+640
Bulloak Woodland	Woodland	100	0	0	0	0	0	-100
Sheltered Grey Gum Woodland	Woodland	0	0	13	30	36	117	+117
Drooping Sheoak Woodland	Woodland	1	0	0.2	28	28	28	+27
Paperbark Woodland	Woodland	19	0	0.1	3	17	23	+4
	Total	**1251**					**2003**	
Forest Redgum Riparian Woodland	Riparian/Floodplain	51	0	0	6	28	29	-22
Swamp Oak Riparian Forest	Riparian/Floodplain	1	0	0	0	0	0	-1
Rough-barked Apple Woodland	Riparian/Floodplain	0	6	7	16	16	24	+24
	Total	**52**					**53**	
Weeping Myall Woodland	Shrubland	0	0	0	0	0	17	+17
Coast Myall Exposed Woodland	Shrubland	<1	0	0	0	0	0	-<1
	Total	**<1**					**17**	
Grassland	Grassland	934	1	5	17	23	114	-820
	Total	**934**					**114**	

The post-mining vegetation community composition of the Proposed Disturbance Area will be different to the current composition. In general, opportunities to alter the extent of current vegetation communities have been used to increase the representation of desired vegetation communities, or decrease the extent of undesirable vegetation communities. For example, the revegetation and regeneration works will aim to reduce the area of Grassland within the post-mining landscape, replacing this mostly with woodland communities, as well as riparian communities where suitable. This will provide increased fauna habitat within the post-mining Study Area, while still retaining small pockets of Grassland throughout the landscape. Such an increase in woodland vegetation will benefit many threatened species identified within the Study Area, particularly small woodland birds and bat species.

The dominant vegetation community within the post-mining landscape will be the Ironbark Woodland Complex. Slaty Box Woodland will also be replanted in large sections. One of the additions to the post-mining landscape of the Proposed Disturbance Area will be the large areas of Sheltered Grey Gum Woodland (**Figure 9.1**). This vegetation community does not presently occur within the Proposed Disturbance Area, however areas within the final post-mining landform will be very suitable for the establishment of this community, particularly the steeply-sloping areas surrounding the final voids.

Similarly, Forest Red Gum Riparian Woodland has been included within the post-mining landscape, to make best use of the low-lying gully habitat branching off Big Flat Creek within the final landform (see **Figure 9.1**). Furthermore, River Red Gum Woodland, a vegetation community not present in the Study Area but recorded nearby, is proposed for re-establishment near Sandy Creek (**Figure 9.1**).

A number of areas within the Study Area have been identified as being of archaeological significance. Where such areas overlap with areas identified for revegetation, such works have the potential to impact archaeological deposits by disturbing the soil surface. Wherever planned revegetation coincides with sites of archaeological significance, non-disruptive methods of revegetation will be used. This is likely to involve natural regeneration or, potentially, hand-planting to minimise the potential for disturbance.

9.4.2 General Biodiversity Management Strategies

A number of general management strategies will be employed across the Study Area to limit the impact of the Project on flora and fauna species. These include the strategies addressed in the following sub-sections.

9.4.2.1 Fencing

Areas of retained vegetation within the Proposed Offset Areas, corridor areas and pre-mining Proposed Disturbance Area will be appropriately protected from human-induced impacts such as damage to vegetation from vehicles or trampling, increased rubbish dumping and alteration to normal fauna behaviour patterns due to human presence. As appropriate, fencing will be used to protect existing vegetation from accidental disturbance and will clearly identify areas of vegetation to be retained. The type of fencing used will consider the need for facilitation of fauna movement.

Fencing will also be used as part of the revegetation strategy to control impacts such as grazing and to allow vegetation to regenerate naturally. This option will be used where active disturbance to the soil for replanting is not considered appropriate, such as in areas of archaeological significance, or in other places where significant tree cover remains. In such cases, sensitive areas can be fenced to exclude stock and to allow native vegetation to occur. Sensitive weed management would also be incorporated to remove unwanted species.

9.4.2.2 Weed Species

Weed species may be brought into the Study Area with imported materials, or encouraged to invade naturally through removal of native vegetation. The presence of weed species has the potential to be a major hindrance to revegetation and regeneration activities. In addition to this, the presence of weed species within the Proposed Offset Areas and corridor areas has the potential to significantly decrease the value of this vegetation to native species, particularly threatened species.

A Weed Management Strategy will be incorporated into the Ecological Management Plan, to detail types of weeds present, required control methods and frequencies, as well as the monitoring requirements across the Study Area.

9.4.2.3 Introduced Fauna Species

Introduced fauna species such as foxes, rabbits and feral cats may increase within the Study Area due to the alteration in existing land use. Clearing, thinning of vegetation and the creation of tracks through existing dense vegetation may assist penetration of introduced fauna species such as cats and foxes, and allow them to establish in new areas. An increase in feral species within the Study Area has the potential to cause considerable impacts on existing native species. In addition to this, a number of introduced herbivores have been recorded within the Study Area, and are likely to be competing with native species, and causing considerable damage to vegetation.

A Pest Species Management Strategy will be incorporated into the Ecological Management Plan to assess target species present, required control methods and frequencies, as well as the monitoring requirements across the Study Area.

9.4.2.4 Bushfire Management

The exclusion of bushfire from revegetation and regeneration areas will be necessary to allow replanted communities to successfully establish. Inappropriate bushfire regimes have the potential to significantly alter the structure and floristics of vegetation communities, and these should be avoided, wherever possible.

9.4.2.5 Adaptive Management

A strong positive feedback loop between monitoring and adaptive management will be established. The management of the ecological components of the Project will be responsive to any new ecological data that may arise through the ecological monitoring of the Study Area, or any other studies completed as part of the Project. This will enable a flexible approach to the management requirements of the Project, allowing ongoing feedback and refinement of the management strategy.

9.4.3 Tree Felling Procedure

A detailed Tree Felling Procedure will be implemented to minimise the potential for impact on native fauna species (including threatened species) as a result of the clearing of hollow-bearing trees. This procedure will be provided within the Ecological Management Plan, and will consider a number of factors, including seasonal considerations (particularly the avoidance of clearing during breeding seasons), the opportunity for salvage and re-use of existing hollows, and the salvage of specific habitat features such as hollow logs, fallen timber and rocks to relocate to other parts of the Study Area. The procedure will detail the necessary pre-clearing activities, requirements during clearing operations, and post-clearing requirements.

9.4.4 Management of Aquatic Habitat

A number of strategies will be assessed for incorporation into the design of the reconstruction of the channel to provide for instream aquatic habitat to mitigate the impact from the removal of Anvil Creek and Clarks Gully. Such strategies include the:

- re-instatement of native aquatic flora communities in water management structures adjacent to Big Flat Creek, as well as within the reconstructed drainage channels of Anvil Creek and other final landform drainage;
- design and construction of all water management structures with shallow verges allowing the colonisation of aquatic macrophytes and sedges;
- where possible, incorporation of meander design and features contributing to habitat complexity (for example pool and riffle sequences, snags, shade etc) in the design of the final landform; and
- monitoring of the enhanced aquatic habitat within the reconstructed drainage channel and other water management structures.

9.5 Biodiversity Offset Strategy

This Section details the Biodiversity Offset Strategy, which was developed to supplement the standard impact mitigation strategies described above, and to provide further mitigation for the predicted impacts of this Project. This Biodiversity Offset Strategy consists of a number of strategies, each designed to provide mitigation for a particular impact. The components of this strategy are intended to combine with the existing standard mitigation strategies, to achieve the overall goal of no net loss of flora and fauna values in the area in the medium to long term.

The Biodiversity Offset Strategy consists of a number of additional mitigation strategies designed to address the identified pre-mitigation impacts on key threatened species, as summarised in **Section 8.11**. These measures include:

- Immediate establishment and protection of Proposed Offset Areas (refer to **Section 9.5.2** and **Figure 9.2**) to allow for the conservation of large areas of existing vegetation within the Study Area;
- Conceptual Corridor Strategy, including augmentation of existing vegetation to improve existing corridor function (refer to **Section 9.5.4** and **Figure 9.3**);
- Augmentation of existing vegetation to increase habitat quality, including provision of nest boxes, fallen timber and specific foraging features for target key threatened species; and
- Development of a detailed Ecological Monitoring Strategy for the life of the mine.

Each of these strategies is discussed in further detail later in this Section.

9.5.1 Background on Offsetting Principles

The conservation of biodiversity values often conflicts with economic development. The NSW Department Environment and Conservation (DEC) discusses biodiversity offsets as being

Biodiversity offsets are defined by DEC as being “one or more appropriate actions that are put in place to counterbalance (offset) the impacts of development on biodiversity.” (DEC 2006as)

The Bio-Banking Background Paper (DEC 2006at) discusses offsets as only being used where impacts cannot be avoided, ideally being undertaken before the development proceeds to ensure they will be effective in delivering no net loss of biodiversity and being located according to biodiversity priorities in the area. The Bio-Banking Working Paper (DEC 2005), draws on offset principles discussed in the Green Offsets for Sustainable Development: Concept Paper (EPA 2002) as follows:

- Environmental impacts must first be avoided by using all cost-effective prevention and mitigation measures. Offsets are only then used to address remaining environmental impacts;
- All standard regulatory requirements are met;
- Offsets must not reward ongoing poor environmental performance;
- Offsets will complement other government programs; and
- Offsets must result in a net environmental improvement.

In addition, the principles suggest that offsets should be:

- Enduring – offset the impact of the development for the period that the impact occurs;
- Quantifiable – the impacts and benefits must be reliably estimated;
- Targeted – they must offset the impacts on a “like for like or better” basis;
- Located appropriately – they must offset the impact in the same region;
- Supplementary – beyond existing requirements and not already be funded by another scheme; and
- Enforceable – through development consent conditions, license conditions, covenants or a contract.

In the absence of any other government principles or criteria for developing offset strategies, and pending the finalisation by the finalisation by DEC of the biodiversity and banking scheme, the above criteria were considered in the development of the Anvil Hill Biodiversity Offset Strategy.

9.5.2 Mitigation through the Protection of the Proposed Offset Areas

9.5.2.1 Introduction

The Proposed Offset Areas is proposed as an immediate ecological outcome to offset the impacts of the Project. It will assist in the protection of a diverse range of threatened flora and fauna species, two endangered populations and one EEC, and will link in with the Conceptual Corridor Strategy, habitat augmentation and Ecological Management Plan to provide for the continued viability of the biodiversity of the Wybong Uplands area. These further impact mitigation strategies, including the Conceptual Corridor Strategy and habitat augmentation, are detailed in **Section 9.5**, while monitoring is further detailed in **Section 10**.

9.5.2.2 Ecological Significance of the Proposed Offset Areas

The Proposed Offset Areas covers an area of 1924 hectares, of which 1037 hectares are covered by treed vegetation (**Figure 9.2**). The largest area is the southern Proposed Offset Areas around Limb of Addy Hill (Area A), which is for the most part covered by intact treed vegetation. Other significant treed areas comprise Anvil Hill (Area B) and Wallaby Rocks (Area C), while the Proposed Offset Areas around Big Flat Creek (Area E) and in the north-east (Area F) and east (northern Area G) of the Study Area are covered by fragmented woodlands. The Proposed Offset Areas in the south-east (southern Area G) has been extensively cleared, with only a few relatively small remnants remaining. An additional area of approximately 20 hectares has been included as a potential Cultural Heritage offset that may have some ecological value. This area currently contains approximately 6 hectares of Ironbark Woodland Complex and has been identified as part of Corridor Option 1 (see **Section 9.5.4.3**).

It is proposed that 1078 hectares of the Proposed Offset Areas will be protected and managed as a Conservation Area whilst 629 hectares of Habitat Enhancement Area will be subject to extensive regeneration and revegetation (**Figure 9.4**). A small area of 217 hectares in the south-east will be managed for agriculture due to the presence of areas of high land capability that will support agricultural production.

The protected part of the Proposed Offset Areas will have its viability as a conservation area secured in the long term. The mechanism for securing this conservation will be determined in consultation with DoP and DEC.

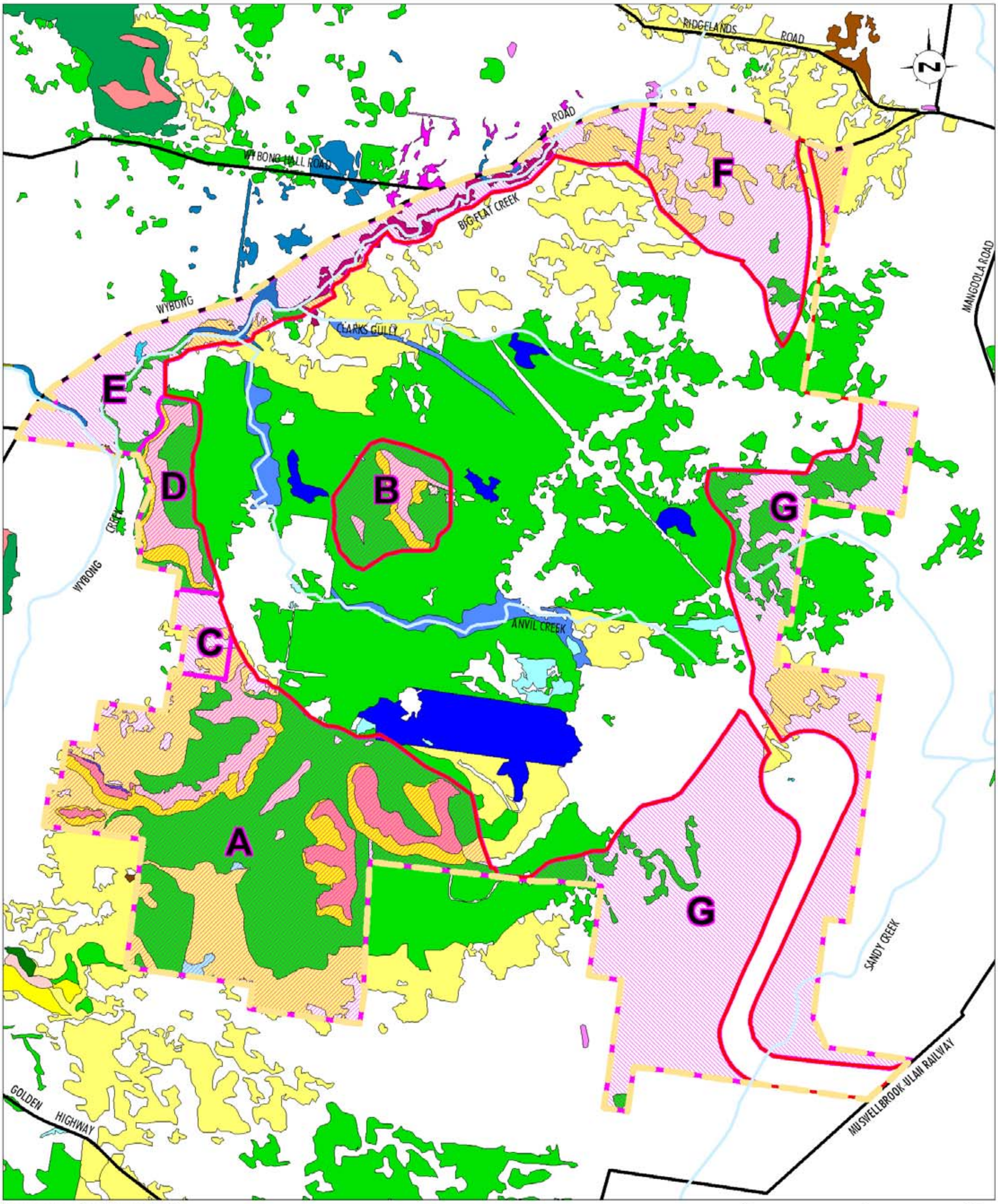
Vegetation and Vegetation Communities

About 1032 hectares (44%) of the 2336 hectares of tree-dominated vegetation present in the Study Area will be protected within the Proposed Offset Areas. In general, the Proposed Offset Areas will protect a much more intact large remnant of bushland than occurs in the Proposed Disturbance Area. In particular, the southern part of the Proposed Offset Areas supports a large area of intact bushland that comprises a range of vegetation communities, most of which have been extant since at least the 1930s. This area, as well as the vegetation around Anvil Hill and Wallaby Rocks, is the oldest vegetation present in the Study Area, and some areas could potentially be old growth, that is vegetation that has been present since before European settlement. The Proposed Offset Areas along Big Flat Creek (Area E) is much more fragmented, but supports significant riparian vegetation, including an EEC.

The Proposed Offset Areas will facilitate the protection of most of the vegetation community types that will be removed from the Proposed Disturbance Area. **Table 4.5** shows that of the 15 natural vegetation communities present in the Study Area (excluding Exotic Rushland and Disturbed Grassland), 12 will be well-represented within the Proposed Offset Areas from between 50% and up to 100% of their extent. Four communities will be protected to lower levels, ranging from 36% of their extent down to 0%.

Of the ten vegetation communities that will be entirely, or mostly, protected within the Proposed Offset Areas, four are of botanical significance. These are documented below:

- Weeping Myall Woodland covers about one hectare of vegetation in three patches, two of which occur within the Proposed Offset Areas. The third patch of this vegetation occurs within the Proposed Disturbance Area, within the centre of the proposed rail loop. As a result of this location, this community is expected to be able to be protected within the centre of the rail loop. This community is listed as an EEC under the TSC Act 1995,



Source: PEAKE (2006)

0 1 2 km

Legend

- Proposed Disturbance Area
- Study Area

- Slaty Box Woodland
- Ironbark Woodland Complex
- Bulloak Woodland
- Exotic Rushland
- Sheltered Grey Gum Woodland
- Weeping Myall Woodland
- Spotted Gum Open Forest
- Ironbark-Wattle Low Exposed Woodland Complex
- Red Ash Sheltered Forest
- Swamp Oak Riparian Forest
- Disturbed Grassland
- River Oak Riparian Forest
- Rough-barked Apple Woodland
- Tall Mixed Shrubland Complex
- Coast Myall Exposed Woodland
- Forest Red Gum Riparian Woodland
- Mixed Species Revegetation/ Plantation
- Drooping Sheoak Woodland
- Paperbark Woodland
- Cypress Pine Woodland
- Low Shrubland
- Currawang Tall Woodland

FIGURE 9.2

Offset Management Units

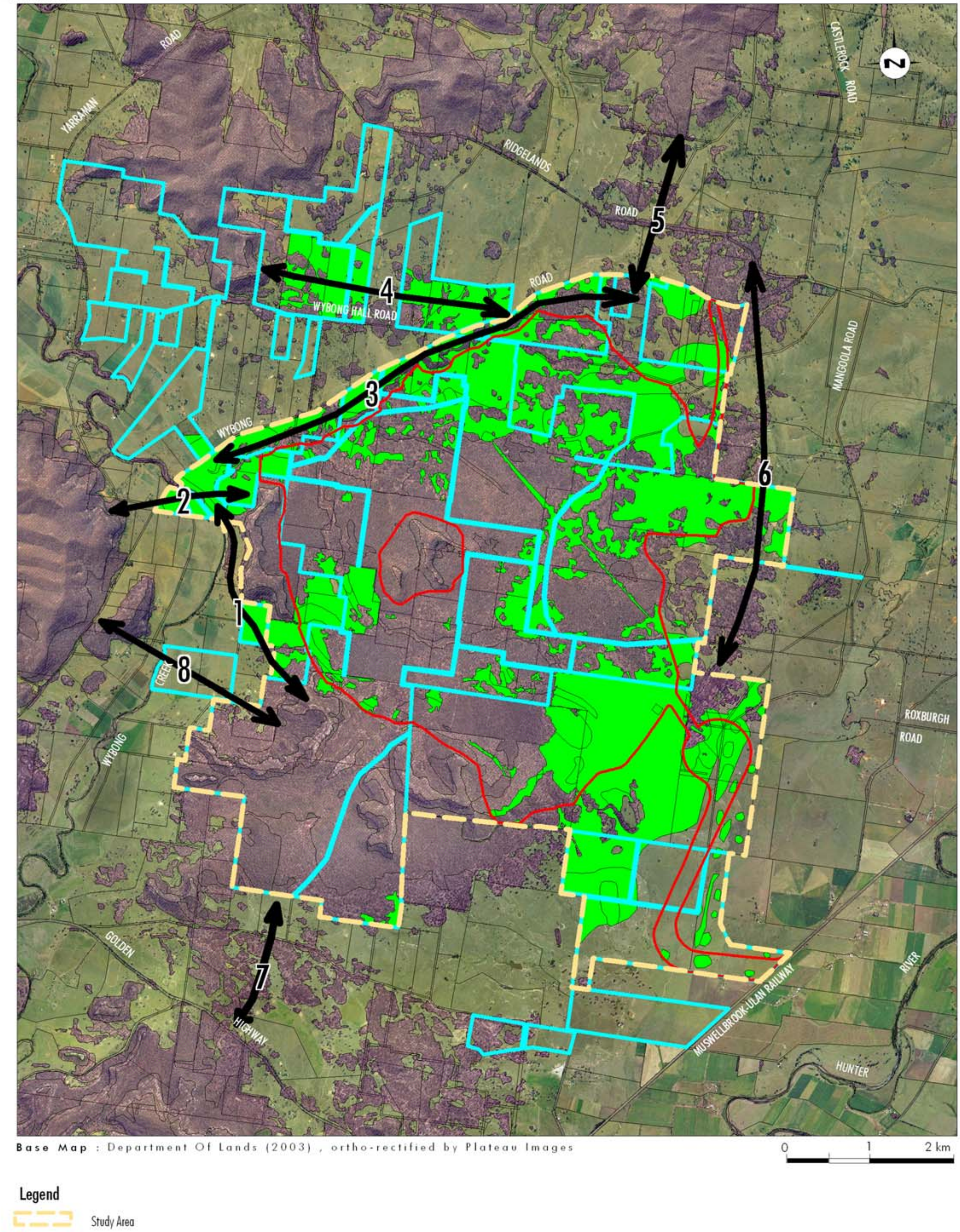
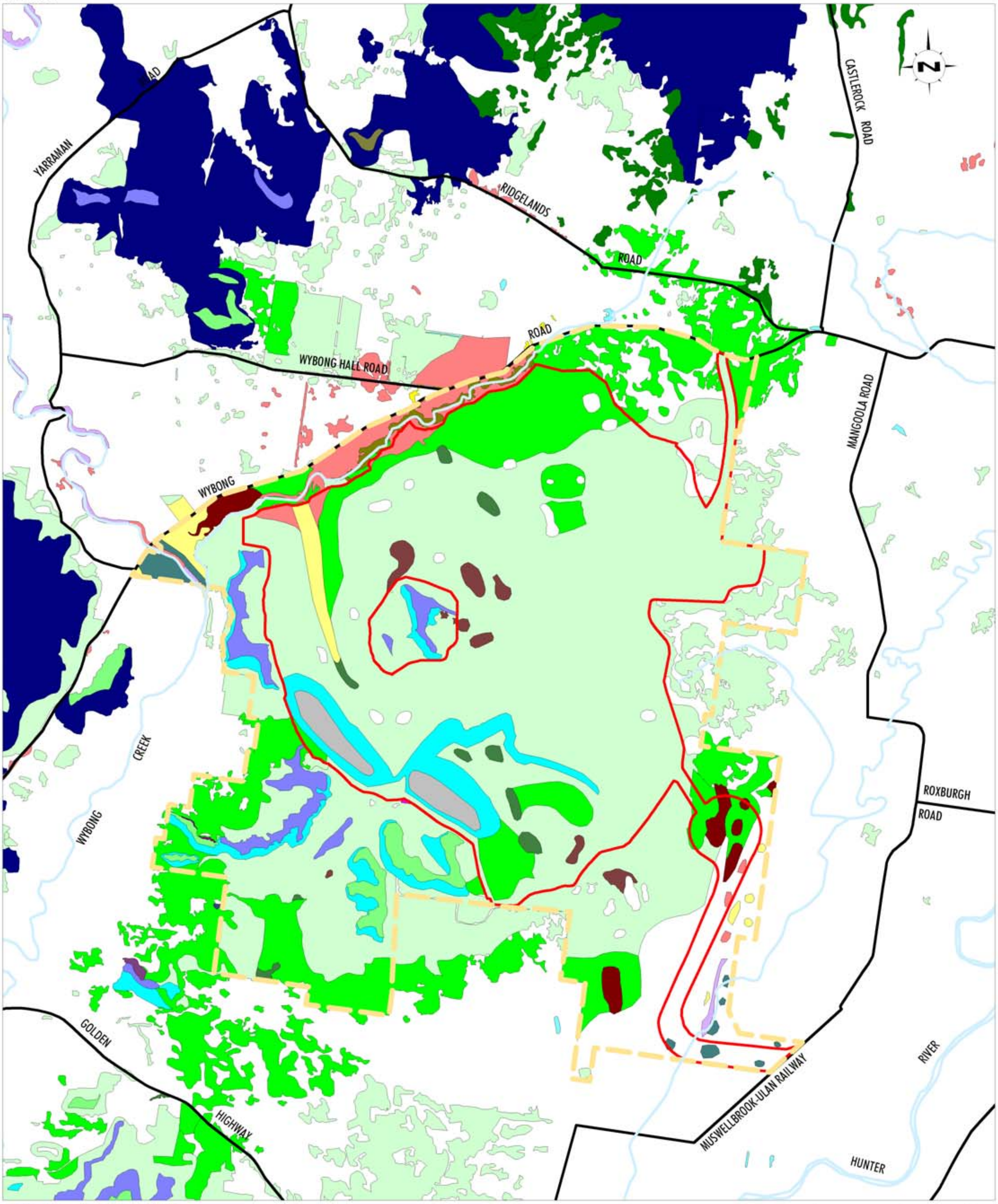


FIGURE 9.3

Conceptual Corridor Strategy



Source: Peake (2006)

Legend

- Proposed Disturbance Area
- Study Area

- Slaty Box Woodland
- Ironbark Woodland Complex
- Bulloak Woodland
- Exotic Rushland
- Sheltered Grey Gum Woodland
- Weeping Myall Woodland
- Spotted Gum Open Forest
- Ironbark-Wattle Low Exposed Woodland Complex
- Red Ash Sheltered Forest
- Swamp Oak Riparian Forest
- River Oak Riparian Forest
- Rough-barked Apple Woodland
- Tall Mixed Shrubland Complex
- Coast Myall Exposed Woodland
- Forest Redgum Riparian Woodland
- Mixed Species Revegetation/Plantation
- Drooping Sheoak Woodland
- Paperbark Woodland
- Cypress Pine Woodland
- Low Shrubland
- Currawang Tall Woodland
- River Red Gum Floodplain Woodland
- Disturbed Grassland
- Final Void

FIGURE 9.4

Revegetation Strategy

and is not protected elsewhere in its occurrence in the Hunter Valley, where it is present at approximately 15 locations (Peake 2006). Thus, the protection of this community as an outcome of the Project will be of conservation significance.

- Paperbark Woodland occurs in a number of discrete patches throughout the Study Area, but also grades in to Ironbark Woodland Complex and is mapped as such in many areas. Within the Proposed Offset Areas two patches covering three hectares occur, although further occurrences mapped as part of Ironbark Woodland Complex are present. This community is regarded as being of regional significance, and may warrant nomination for listing once further data are collected (Peake 2006).

- Swamp Oak Riparian Forest covers almost 20 hectares within the Proposed Offset Areas, as opposed to about one hectare in the Proposed Disturbance Area. Swamp Oak Riparian Forest is regarded as highly cleared and warranting listing as an EEC under the TSC Act 1995 and EPBC Act 1999 by Peake (2006).

- River Oak Riparian Forest covers 0.5 hectares within the Proposed Offset Areas, and is not present in the Proposed Disturbance Area. River Oak Riparian Forest is regarded as very highly cleared and warranting listing as an EEC under the TSC Act 1995 and EPBC Act 1999 by Peake (2006).

Flora Species and Populations

The Proposed Offset Areas will offer the opportunity to protect a number of threatened plant species which are very poorly protected elsewhere or, in many cases, not protected at all.

Figure 4.5 shows that five threatened flora species occur within the Proposed Offset Areas. Of these, painted diuris (*Diuris tricolor*) occurs at a number of locations between Muswellbrook and Wybong, and is under threat from development, weed invasion and agriculture (Peake 2006). This species was recorded from one site in low numbers close to Big Flat Creek, in the northern Proposed Offset Areas. It is expected however that it would occur more extensively across the Proposed Offset Areas in areas of open woodland and grassland that have not been grazed for a number of years. Such areas are likely to occur in the north-east, east and south-east of the Proposed Offset Areas.

The remaining four threatened flora species all occur in highly restricted locations in the upper Hunter Valley (Peake 2006). They are collectively only poorly represented in conservation reserves, with most being present on Crown Land in the Sandy Hollow – Denman – Aberdeen district. In particular, *Commersonia rosea* is a recently-described species previously known from only four sub-populations in the Sandy Hollow district (Bell and Copeland 2004). The record of this species in the Proposed Offset Areas extends the species' known range by about seven kilometres and represents a significant conservation opportunity.

In addition, the Proposed Offset Areas supports the only known stands of the ROTAP shrub mountain grevillea (*Grevillea montana*) in the Study Area, and will assist in the protection of this regionally significant species.

Narrow goodenia (*Goodenia macbarronii*) has not been recorded within the Proposed Offset Areas. This species is ephemeral, and not possible to identify outside of its unpredictable flowering periods, therefore it is considered to be highly likely that the species will be present in some parts of the Proposed Offset Areas, particularly in areas of open woodland and grassland that have not been grazed for a number of years.

Two endangered plant populations occur within the Proposed Offset Areas: weeping myall (*Acacia pendula*) and tiger orchid (*Cymbidium canaliculatum*). Both species that form the populations occur broadly across the floor of the Hunter Valley in small, species-poor sub-populations (Peake 2006). Weeping myall has been recorded from two sub-populations, one from the Proposed Disturbance Area, the other from the Proposed Offset Areas. This species has also been recorded outside of the Study Area, in the local area (**Figure 4.5**). Tiger orchid has been recorded from four sub-populations within the Proposed Disturbance Area and from 13 sub-populations in the Proposed Offset Areas. As the weeping myall population is not known to occur within any conservation reserves, and the tiger orchid population is only known to be very poorly reserved (Peake 2006), the protection of the Proposed Offset Areas would offer a significant opportunity to protect the endangered populations of both species.

Fauna Habitat

The Proposed Offset Areas comprises a diverse array of fauna habitats, and includes representation of all four vegetation formations mapped in the Study Area. A summary of the key characteristics each of the four formations as they relate to threatened fauna habitat follows.

The Woodland formation does not, in general, differ significantly between the Proposed Disturbance Area and Proposed Offset Areas. Notwithstanding this, the Proposed Offset Areas supports more mature, ecologically diverse Woodland, which is most likely the result of a longer post-clearing interval. This is evidenced by a relatively high average DBH of trees, as well as the significantly higher habitat tree density. This highlights the increased value of the habitat within the Proposed Offset Areas for hollow-dependent species, particularly a number of the identified key threatened species. The generally high levels of fallen timber in the form of logs and stumps is likely to provide increased foraging potential for a number of key threatened species, particularly insectivorous woodland birds and terrestrial mammal species.

The Riparian/Floodplain formation in the Proposed Offset Areas does not support the old growth vegetation that is present in the Proposed Disturbance Area. The Proposed Offset Areas does support a variety of age classes, with middle-aged to mature vegetation dominating in most areas. The lower DBH of the vegetation of the Proposed Offset Areas, as well as the lack of habitat trees are characteristic of the generally younger vegetation, means that tree hollows and other critical habitat features for many of the key threatened fauna species are of low abundance in this formation.

The Shrubland formation provides important foraging value for a number of nectarivorous key threatened species, such as the squirrel glider (*Petaurus norfolcensis*). This vegetation formation would be most beneficial as fauna habitat where it adjoins woodland formations, where species are able to descend from the canopy and forage in the mid-storey shrubs. The open nature of the shrub layer is also likely to benefit a number of threatened woodland bird species, as it provides an open mid-layer for foraging.

The Grassland formation does not differ significantly between the Proposed Disturbance Area and Proposed Offset Areas. While the value of this formation for key threatened species is low, the Grassland formation does provide open foraging areas, particularly in areas that lie on the fringes of existing vegetation. Such open areas in proximity to protective vegetated cover are likely to benefit woodland bird species, whereby short foraging periods would be spent in the Grassland with birds frequently returning to the protective cover of nearby woodland.

In conclusion, despite the more restricted area of fauna habitat available in the Proposed Offset Areas, there is a general higher quality of habitat present for most of the key threatened fauna species, except in the Riparian/Floodplain formation, where the relative quality of the habitat is substantially poorer. Centennial's contribution to riparian enhancement in the general area as part of the Wybong Uplands Land Management Strategy (refer to **Section 9.5.5**), will contribute to the offsetting of these impacts.

Fauna Species

Nineteen threatened fauna species were recorded in the Study Area (**Figure 5.1**), of which 13 species are known to occur within the Proposed Disturbance Area and 16 species in the Proposed Offset Areas. Of these, the brush-tailed rock-wallaby (*Petrogale penicillata*) was recorded from old scats, and is regarded as being locally extinct, as evidenced by the lack of observations during the extensive surveys which failed to detect any further signs of occupation.

The Proposed Offset Areas provides known or potential habitat for most of these threatened fauna species. The structurally intact woodland in the southern Proposed Offset Areas supports habitat for at least 16 threatened fauna species, most of which prefer ecologically mature woodland (mostly due to hollow-dependence) but some species such as the hooded robin (*Melanodryas cucullata cucullata*) that require more fragmented woodland edges. The Proposed Offset Areas around Anvil Hill and Wallaby Rocks also support ecologically mature woodland as well as shrubland, which in turn support significant populations of a number of threatened fauna species, particularly woodland birds such as the speckled warbler (*Pyrrholaemus sagittata*), grey-crowned babbler (*Pomatostomus temporalis temporalis*) and brown treecreeper (*Climacteris picumnus victoriae*), as well as the feed tree dependent glossy black-cockatoo (*Calyptorhynchus lathami*).

The more fragmented Proposed Offset Areas around Big Flat Creek (Area E) supports riparian and woodland vegetation, which provides important habitat for all five recorded threatened woodland birds, while the fragmented woodlands in the north-east (Area F) and east (northern Area G) of the Proposed Offset Areas also provide good habitat for these species.

The only threatened fauna species that were recorded in the Proposed Disturbance Area but not in the Proposed Offset Areas were the turquoise parrot (*Neophema pulchella*) and greater broad-nosed bat (*Scoteanax rueppellii*).

The koala (*Phascolarctos cinereus*) was recorded by scat identification around Limb of Addy Hill in the southern Proposed Offset Areas. Despite extensive searches (**Section 3.5.1.4**) this species was not located visually or audibly anywhere in the Study Area. It was concluded that while the species is likely to be present in the southern Proposed Offset Areas, it probably occurs in very low numbers and is unlikely to use the vegetation of the Proposed Disturbance Area.

Four EPBC-listed migratory bird species (other than those listed as threatened under the TSC Act 1995 or EPBC Act 1999) were recorded in the Study Area (**Figure 5.1**), of which three species are known to occur within the Proposed Disturbance Area and two species in the Proposed Offset Areas. The Proposed Offset Areas provides important habitat for all of these species, although it is expected that the white-bellied sea-eagle (*Haliaeetus leucogaster*) would occur only occasionally. The rainbow bee-eater (*Merops ornatus*) was recorded predominantly from the Proposed Offset Areas around Big Flat Creek and the southern Proposed Offset Areas, while the white-throated needletail (*Hirundapus caudacutus*) and satin flycatcher (*Myiagra cyanoleuca*) were each recorded once only from the Proposed Offset Areas and the Proposed Disturbance Area, respectively.

Aquatic Habitat

The Proposed Offset Areas supports significant aquatic habitat in Big Flat Creek (Area E in **Figure 9.2**), which will be protected through the Biodiversity Offset Strategy. The creek is well defined with channel widths in the order of 20 to 100 metres) with bank heights generally in the order of 2 to 6 metres. Minor erosion of banks and the channel was observed during site inspections and salt scalding of the adjacent floodplain was also evident.

Big Flat Creek has well developed riparian vegetation dominated by swamp oak (*Casuarina glauca*) and in channel vegetation dominated by common reed (*Phragmites australis*), bullrush (*Typha orientalis*) and the introduced sharp rush (*Juncus acutus* subsp*. acutus*), as well as some submerged aquatics in low flow pools.

A range of in-stream aquatic habitats were recorded including pools up to 25 metres in length, pool and riffle sequences, woody debris and detritus. Big Flat Creek provides habitat for moderate numbers of small fish.

Other parts of the Proposed Offset Areas support only ephemeral gullies or highly cleared and modified agricultural areas.

9.5.3 Revegetation and Regeneration Strategy

Revegetation and regeneration will form a major element of the Biodiversity Offset Strategy for the Project and will contribute significantly towards the progressive rehabilitation of previously mined areas, provision of corridors, habitat augmentation and impact 'softening' strategies. The overall benefits will be to replace habitat lost from the Proposed Disturbance Area. Additional habitat will also be established within the Proposed Offset Areas and corridor areas.

The following Table provides the indicative final composition of vegetation communities following augmentation of habitat within the Proposed Offset Areas.

Table 9.2 - Indicative Final Composition of Vegetation within the Proposed Offset Areas following Habitat Augmentation Works

Community Name	Formation	Extent of Existing Vegetation (ha)	Extent of Vegetation following Augmentation (ha)	Net Change in Vegetation Extent (ha)
Slaty Box Woodland	Woodland	281	392	+111
Ironbark Woodland Complex	Woodland	507	777	+270
Bulloak Woodland	Woodland	0	0	0
Sheltered Grey Gum Woodland	Woodland	79	79	0
Red Ash Sheltered Forest	Woodland	1	1	0
Mixed Species Revegetation/Plantation	Woodland	1	1	0
Drooping Sheoak Woodland	Woodland	1	6	+5
Paperbark Woodland	Woodland	3	3	0
Total		**873**	**1259**	
Exotic Rushland	Riparian/ Floodplain	0		0
Swamp Oak Riparian Forest	Riparian/ Floodplain	20	22	+2
River Oak Riparian Forest	Riparian/ Floodplain	1	6	+6
Rough-barked Apple Woodland	Riparian/ Floodplain	11	60	+49

Table 9.2 - Indicative Final Composition of Vegetation within the Proposed Offset Areas following Habitat Augmentation Works (cont)

Community Name	Formation	Extent of Existing Vegetation (ha)	Extent of Vegetation following Augmentation (ha)	Net Change in Vegetation Extent (ha)
Forest Redgum Riparian Woodland	Riparian/ Floodplain	0	23	+23
River Red Gum Floodplain Woodland	Riparian/ Floodplain	0	22	+22
Total		**32**	**133**	
Weeping Myall Woodland	Shrubland	1	30	+29
Tall Mixed Shrubland Complex	Shrubland	52	52	0
Coast Myall Exposed Woodland	Shrubland	74	74	0
Total		**127**	**156**	
Grassland	Grassland	872	357	-515
Total		**872**	**357**	

As identified in **Section 9.4.1**, regeneration or hand-planting techniques will be used in areas of archaeological significance to minimise the potential for disturbance.

In all cases, the following will be applicable to all revegetation activities, as well as regeneration where relevant:

- All revegetation and regeneration will be established as soon as possible to minimise lag time in habitat replacement;
- All replanting within revegetation areas will be appropriately designed with structural and floristic diversity suitable to complement nearby existing vegetation communities;
- All revegetation will use species from an acceptable level of local provenance (as described in **Section 9.3.5.2** below);
- All revegetation and regeneration areas will be subject to appropriate regular management (weeding, replacement of failed plantings, bushfire protection);
- All revegetation and regeneration areas will be subject to appropriate regular monitoring (success/failure) and a positive feedback loop to Centennial and relevant government agencies (discussed in **Section 10.1**); and
- All areas of revegetation and regeneration will be appropriately protected.

9.5.3.1 Timing of Revegetation and Regeneration

Any areas of planned revegetation or regeneration will be established as early as possible within the life of the Project. The early establishment of revegetation will ensure that replanted vegetation will be mature enough to function as fauna habitat as early as possible. All corridor plantings will be established as soon as possible within the life of the Project, with priority placed on those corridors that will facilitate fauna movement in front of the advancing mine.

The benefit of early establishment will be that this vegetation will become available as habitat as quickly as possible. While a number of fauna species would be able to make some use of young plantings, it is likely to be at least 10-20 years before such areas will form vegetation communities of suitable maturity and complexity to provide habitat for resident fauna species, particularly threatened species.

9.5.3.2 Use of Local Provenance Species in Revegetation

The revegetation of the Proposed Disturbance Area, Proposed Offset Areas and Corridor Strategy will use local provenance species, unless conditions such as seed availability or climate demand the use of non-local provenance species, retaining the gene pool of the Wybong Uplands as much as possible. Where this is restrictive, material from a wider geographic range will be used.

9.5.4 Conceptual Corridor Strategy

The Project will require the removal of the existing vegetation from the Proposed Disturbance Area for the purpose of mine construction and operation. The removal of this vegetation will result in a reduction in the existing vegetated connectivity throughout the Study Area, restricting movement opportunities for flora and fauna species to the retained vegetation around the perimeter of the Proposed Disturbance Area.

The Conceptual Corridor Strategy was developed in order to address this reduction in movement opportunities. In doing so, the strategy has aimed to identify existing corridors within the landscape and to retain this existing function wherever possible. Where this has not been possible, alternative corridor options have been provided to ensure adequate access and egress throughout the Study Area during the construction and operation of the mine, as well as in the post-mining landscape.

The Conceptual Corridor Strategy consists of a number of individual corridor options, each designed to function as movement corridors and to provide options to conserve and enhance existing vegetation within the corridor system. The strategy has been designed to allow for the movement of a number of target threatened fauna species, particularly those that have been identified as key threatened species for this impact mitigation strategy.

From this, corridor options have been designed to contain necessary habitat features required by the key threatened species, and to be wide enough to provide adequate high-quality habitat to allow the protected movement of these species through the length of the corridor. The design of these corridor options has also considered the provision of sufficient habitat variation to conserve the different ecological characteristics of the Study Area, wherever possible.

These corridor options will also allow for the movement of flora species via the movement of genetic material (pollen and seeds) through vectors such as wind, water, birds, mammals and insects. The Conceptual Corridor Strategy will provide significant movement opportunities for all threatened plants recorded in the Study Area, and allow these to move and colonise new areas over time.

9.5.4.1 Existing Identified Corridors

Peake (2006) identified recommended regional linkages within the central Hunter Valley and, as such did not identify existing corridors, rather discussed opportunities for the creation of regional linkages. Peake (2006 – Figure 5.45) included the Study Area in a recommended regional linkage that extended approximately 10 kilometres to the south and 10 to 15 kilometres to the north. The Study Area occurs close to the western boundary of Peake's (2006) study area and extension of the recommended regional linkage to the west and north-west beyond the Peake (2006) study area was suggested. The recommended regional linkage including the Study Area did not extend to the east.

Peake (2006) also identified recommended sub-regional and local linkages within the Central Hunter Valley that included six recommended sub-regional and local linkages between the Study Area and adjoining vegetation (Peake 2006 – Figure 5.46). The recommended sub-regional and local linkages mapped by Peake (2006) includes recommended linkages; to the south across the Golden Highway, to the west from Wallaby Rocks, to the north-west across Denman Road, to the north across Denman Road, and to the east towards Muswellbrook.

The Study Area lies to the south-west of the study area of the NPWS Key Habitats and Corridors Project (Scotts 2003) and is not included in its mapping. The Study Area is also outside the north-western boundary of the "Synoptic Plan – Integrated Landscapes for Coal Mine Rehabilitation in the Hunter Valley of NSW" prepared by the NSW Department of Mineral Resources.

9.5.4.2 Ecological Design Criteria for Conceptual Corridor Strategy

Following the criteria for corridor establishment for fauna developed in north-eastern NSW (Scotts et al. 2000), the following corridor types are included within the Conceptual Corridor Strategy:

- **Regional Corridors:** these corridors are of sufficient width to possess their own ecological integrity, particularly in containing sufficient habitat to support resident populations of target species. Importantly, these corridors are wide enough to contain protected interior habitat, to provide for target species adversely affected by edge effects. This width allows for sub-optimal buffer zones along the edges of the corridors, providing habitat for more tolerant target species. The minimal width for this corridor category within the Project will be 1000 metres, however some narrower sections will be acceptable in certain circumstances.

- **Sub-regional Corridors:** while not as extensive as regional corridors, these remain wide enough to support resident populations of priority target species, or to provide a sizeable link between substantial areas of key habitat. Preferred widths for this corridor type range between 400 and 1000 metres, however a minimum of 300 metres will be provided.

- **Local Corridors:** these corridors tend to be narrower than the preceding categories, and should be designed to connect into wider regional and sub-regional corridors. Corridors of this type are generally less than 500 metres wide.

- **Stepping-stone Patches:** these corridor types are generally not connected to the larger regional and sub-regional corridor systems, however still provide movement opportunities for mobile species (in particular), as well as for the conservation of key habitat within the region. These corridor types do not necessarily contain habitat features for residency of target threatened species, however these features can be provided to enhance the efficacy of these corridors.

Each of these corridor categories are included within the corridor strategy for the Project. This corridor strategy will be supported by the Revegetation and Regeneration Strategy, as identified in **Section 9.5.4** through which appropriate revegetation will be undertaken, and regeneration facilitated.

As with all aspects of these impact mitigation strategies, the importance of early establishment of these corridors will be addressed. The benefits of early establishment revolve around reducing the lag time before the vegetation within these corridors is established and mature enough to become functional, both in terms of fauna movement and of habitat provision and protection.

The conceptual corridor strategy is designed to allow for the movement of flora and fauna to and from the Study Area during the construction and ongoing operation of the Project. The corridor options have been designed to perform the following roles (following Burgman & Lindenmayer 1998):

- Facilitate movement of fauna through sub-optimal habitat;
- Provide habitat for resident flora and fauna populations;
- Provide access to unexploited habitat;
- Allow recolonisation of empty patches to reverse local extinctions;
- Allow immigration to prevent localised extinctions, particularly to small populations; and
- Promote genetic exchange between sub-populations to increase effective population size and reduce potential impacts of genetic drift and inbreeding depression.

In order to achieve these roles, the corridor options have been designed according to the following objectives:

- Be as wide as possible to maximise functioning;
- Be wide enough to provide a protected core area, with external buffer areas;
- Make use of existing vegetation to minimise requirements for revegetation, wherever possible;
- Be structurally and floristically diverse;
- Be planted with appropriate species of local provenance;
- Contain nesting/roosting habitat for target threatened species;
- Link existing vegetation fragments to provide a consolidated vegetated area;
- Have a minimal edge: area ratio, thus reducing impacts from 'edge effects', which lead to the modification of vegetation at the edges of fragments through weed and pest establishment, increased windthrow, increased light levels and exposure to other detrimental impacts;
- Contain minimal gaps, bottlenecks and barriers (roads);
- Be selectively positioned to link appropriate source/sink areas;
- Be regularly managed and monitored; and
- Be appropriately protected.

9.5.4.3 Conceptual Corridor Options

The landscape within and adjoining the Study Area currently consists of a large number of vegetated fragments of varying sizes and levels of connectivity. The size, location and degree of connectivity of these existing fragments have been used to assist in the identification of a number of conceptual corridor options to be included as part of the Biodiversity Offset Strategy for the Project. A total of eight corridor options are assessed as part of this strategy, as identified in **Figure 9.3**. These options are located both within the Study Area (internal corridors providing movement opportunities throughout the Study Area) and outside of the Study Area (external corridors providing movement opportunities in and out of the Study Area).

In a number of areas around (and within) the Study Area, existing vegetation fragments are close enough to form informal corridors that are likely to be currently functioning as 'stepping stone' corridors within the existing landscape. Such corridor types do not necessarily consist of continual vegetated cover, rather contain a number of fragments that are close enough to provide movement opportunities for the more mobile species such as birds and bats. A number of these existing stepping-stone corridors have been recognised as part of the Conceptual Corridor Strategy. Such corridors are highly beneficial as they provide existing movement opportunities throughout the landscape for mobile species, while also providing opportunities for management activities such as revegetation and regeneration to greatly increase corridor function and value.

The following sections identify each of the proposed corridor options, and discuss the relative merits and challenges faced by each. Area values have been provided for each corridor option, based on preferred widths and the cadastral boundaries of the properties involved. Details are also provided on the proportion of each corridor option that is currently Centennial-owned or under Agreement. These properties are identified in **Figure 9.3**. The section then concludes with a discussion on the preferred corridor options from the perspective of maximum ecological function of the Study Area, and identifies the likely mechanisms through which this function will be achieved.

Corridor Option 1 – Southern Offset to Wallaby Rocks

Corridor Option 1 is a partly internal, partly external corridor, linking the Southern Proposed Offset Areas (Area A in **Figure 9.2**) to Wallaby Rocks (Area D). The majority of this corridor falls within the Proposed Offset Areas, however areas in the west of the corridor (outside of the Study Area) were included to provide alternative access around the rugged escarpments of Wallaby Rocks. This option is for a local corridor, and thus will be less than 500 metres wide. This corridor would provide critical connectivity through the Study Area in the face of the advancing mine, allowing fauna in the north-western section of the Proposed Disturbance Area to move south into the Proposed Offset Areas, or west through Corridor Options 2 and 8 into large areas of secure habitat within Manobalai Crown Land. This is a relatively short corridor that contains some areas of existing vegetation to use as 'stepping stones' for revegetation purposes. Such areas of existing vegetation would provide patches of mature vegetation within the revegetation areas of the corridor. This corridor links with two regional corridor options, being Corridor Options 2 and 8, and provides north/south connectivity along the western side of the Study Area.

The total area for this corridor is 102 hectares, of which 20 hectares are currently vegetated (**Table 9.3**). It will therefore require 82 hectares (81%) of the corridor to be revegetated. 15% of this corridor option is currently under Centennial ownership, or is under Agreement with Centennial.

Table 9.3 – Existing Vegetation

Vegetation Community	Formation	Area (ha)
Ironbark Woodland Complex	Woodland	7.1
Sheltered Grey Gum Woodland	Woodland	0.0
Slaty Box Woodland	Woodland	12.3
Total		**19.4**

Corridor Option 1 contains existing vegetation that forms part of the Ironbark Woodland Complex, Sheltered Grey Gum Woodland and Slaty Box Woodland. Appropriate species composition for revegetation for this Corridor will be dominated by species recorded from these vegetation communities.

Corridor Option 2 – Wallaby Rocks to Manobalai Crown Land

Corridor 2 is an external corridor that provides an access/egress route for the Study Area, particularly providing connectivity between the Study Area and Manobalai Crown Land to the west. This Crown Land is a large area of undisturbed vegetation that links directly to Goulburn River National Park and indirectly to Wollomi National Park. This corridor also provides a link between two local internal corridor options (1 and 3) and the Manobalai Crown Land. This corridor option is a potential regional corridor, and is thus at least 1000 metres wide. This is a highly visible, external corridor that would provide an egress route to highly secure lands in front of the advancing mine. Although the presence of Wybong Creek within this corridor might be a minor barrier to the movement of some fauna, it would also provide for increased water availability, and for the potential establishment of river-flat communities such as Forest Red Gum Woodland, River Red Gum Woodland or Weeping Myall Woodland. The large width of this corridor would also reduce edge: area ratio effects.

The establishment of this corridor will be challenged by the lack of 'stepping stone' remnants that would aid in revegetation, as well as the large area requiring revegetation and the potential barrier of Wybong Road.

The total area for this corridor is 134 hectares, of which 13 hectares are currently vegetated (**Table 9.4**). It will therefore require 121 hectares (90%) of the corridor to be revegetated. 38% of this corridor option is currently under Centennial ownership, or is under Agreement with Centennial.

Table 9.4 – Existing Vegetation

Vegetation Community	Formation	Area (ha)
Ironbark Woodland Complex	Woodland	6.6
Rough-barked Apple Woodland	Riparian/Floodplain	4.4
River Oak Riparian Forest	Riparian/Floodplain	2.1
Sheltered Grey Gum Woodland	Woodland	0.1
Total		**13.2**

Corridor Option 2 contains existing vegetation that forms part of the Ironbark Woodland Complex, Rough-barked Apple Woodland, River Oak Riparian Forest and Sheltered Grey Gum Woodland. Appropriate species composition for revegetation for this Corridor will be dominated by species recorded from these vegetation communities. The presence of Wybong Creek within this corridor would allow for further riparian vegetation communities to be established.

Corridor Option 3 – Big Flat Creek

Corridor Option 3 is a highly visible, internal corridor that provides a critical link between the Proposed Offset Areas from the north, through the western parts of the Study Area, to the Southern Proposed Offset Areas. This corridor also provides a link between two major external corridor options (5 and 2), both leading to/from large areas of Crown Land. This is proposed to be a local corridor, thus exhibiting a width of less than 500 metres. This is a long, narrow corridor, constrained on the northern side by Wybong Road, and by the Proposed Disturbance Area boundary to the south. Despite this, the corridor is of high ecological value, as it will contain a riparian area and a variety of existing vegetation communities (including regionally significant communities), and will also protect populations of threatened flora species.

This corridor option currently contains a number of ‘stepping stone’ vegetation fragments, which will assist in revegetation. However, it lies in an area that has been identified as suffering from dryland salinity and extensive riparian weed invasion. The length and shape of the corridor increases the impacts from a high edge area, and the adjoining Wybong Road may present increased impacts from noise and vehicle collision with wildlife. While these present management challenges for this corridor, the ecological value of this option will remain high.

The total area for this corridor is 187 hectares, of which 76 hectares are currently vegetated (**Table 9.5**). It will therefore require 111 hectares (59%) of the corridor to be revegetated. 53% of this corridor option is currently under Centennial ownership, or is under Agreement with Centennial.

Table 9.5 – Existing Vegetation

Vegetation Community	Formation	Area (ha)
Weeping Myall Woodland	Shrubland	0.9
Ironbark Woodland Complex	Woodland	5.8
Swamp Oak Riparian Forest	Riparian/Floodplain	19.7
Rough-barked Apple Woodland	Riparian/Floodplain	8.8
Mixed Species Revegetation/Plantation	Woodland	0.8
Exotic Rushland	Riparian/Floodplain	0.3
Slaty Box Woodland	Woodland	39.6
Total		**76**

Corridor Option 3 contains existing vegetation that forms part of the Weeping Myall Woodland, Ironbark Woodland Complex, Swamp Oak Riparian Forest, Rough-barked Apple Woodland, Mixed Species Revegetation/Plantation, Exotic Rushland and Slaty Box Woodland. Appropriate species composition for revegetation for this Corridor will be dominated by species recorded from these vegetation communities, except for Exotic Bushland, which is dominated by the weed sharp rush (*Juncus acutus* subsp. *acutus*).

Corridor Option 4 – Study Area to Blackjack Mountain Crown Land

Corridor Option 4 is a sub-regional corridor, thus having a minimal width ranging between 400 and 1000 metres. This is a highly visible external corridor that will link the northern Proposed Offset Areas with a large area of highly secure habitat known as the Blackjack Mountain Crown Land. This corridor option also links to two other important corridors, being Corridor Options 5 and 3. This corridor has been located to make optimal use of existing

Centennial-controlled properties, as well as incorporating as much existing 'stepping stone' habitat as possible. This will be a relatively long corridor, however the potential width will decrease the potential edge effects. This corridor option will also provide the opportunity to revegetate areas of regionally significant vegetation, such as Rough-barked Apple Woodland.

Challenges faced by this corridor option include potential barriers from Wybong Road and Wybong Post Office Road, existing dryland salinity and weed invasion issues.

The total area for this corridor is 294 hectares, of which 75 hectares are currently vegetated (**Table 9.6**). It will therefore require 219 hectares (74%) of the corridor to be revegetated. 65% of this corridor option is currently under Centennial ownership, or is under Agreement with Centennial.

Table 9.6 – Existing Vegetation

Vegetation Community	Formation	Area (ha)
Rough-barked Apple Woodland	Riparian/Floodplain	12.0
Ironbark Woodland Complex	Woodland	31.9
Ironbark-Wattle Low Exposed Woodland Complex	Woodland	4.3
Exotic Rushland	Riparian/Floodplain	7.5
Tall Mixed Shrubland Complex	Shrubland	1.1
Slaty Box Woodland	Woodland	17.6
Mixed Species Revegetation/Plantation	Woodland	0.5
Total		**74.9**

Corridor Option 4 contains existing vegetation that forms part of the Rough-barked Apple Woodland, Ironbark Woodland Complex, Exotic Rushland, Tall Mixed Shrubland Complex, Mixed Species Revegetation/Plantation, Slaty Box Woodland, and Ironbark-Wattle Low Exposed Woodland Complex. Appropriate species composition for revegetation for this Corridor will be dominated by species recorded from these vegetation communities, except for Exotic Bushland, which is dominated by the invasive weed sharp rush (*Juncus acutus* subsp. *acutus*).

Corridor Option 5 – Study Area to Northern Crown Land

Corridor Option 5 is a potential regional corridor with a minimum width requirement of 1000 metres. This highly visible external corridor is located to the north of the Study Area and would link the northern Proposed Offset Areas (Area F) to a large area of Crown Land. This Crown Land is likely to be the second-largest area of secure habitat in the region (behind the Manobalai Crown Land), and will be likely to provide a significant recruitment source for the recolonisation of the Proposed Disturbance Area following rehabilitation. There are relatively large numbers of 'stepping stone' fragments in this corridor, which would assist greatly in revegetation efforts. There are two potential road barriers (Wybong Road and Wybong Post Office Road) present in this option, however both have existing fringing vegetation and are likely to be relatively soft barriers due to their existing vegetation, narrowness and relatively low vehicle use. This corridor also makes use of the existing well-vegetated Travelling Stock Reserve (TSR) to the south of Wybong Road.

The main challenge of this option will be the potential conflicts resulting from the proximity to the mine entrance. This may cause increased incidences of vehicle wildlife collisions, and increased disturbance to fauna by traffic in these areas.

The total area for this corridor is 304 hectares, of which 107 hectares are currently vegetated (**Table 9.7**). It would therefore require 198 hectares (65%) of the corridor to be revegetated. None of the properties within this option are currently owned or under agreement with Centennial.

Table 9.7 – Existing Vegetation

Vegetation Community	Formation	Area (ha)
Mixed Species Revegetation/Plantation	Woodland	1.3
Spotted Gum Open Forest	Woodland	9.9
Ironbark Woodland Complex	Woodland	1.6
Slaty Box Woodland	Woodland	88.3
Exotic Rushland	Riparian/Floodplain	0.5
Ironbark-Wattle Low Exposed Woodland Complex	Woodland	0.1
Total		**101.7**

Corridor Option 5 contains existing vegetation that forms part of the Spotted Gum Open Forest, Ironbark Woodland Complex, Slaty Box Woodland, Mixed Species Revegetation/Plantation, Exotic Rushland and Ironbark-Wattle Low Exposed Woodland Complex. Appropriate species composition for revegetation for this Corridor will be dominated by species recorded from these vegetation communities except for Exotic Rushland which is dominated by the invasive weed sharp rush (*Juncus acutus* subsp. *acutus*).

Corridor Option 6 – Eastern Study Area

Corridor Option 6 has been identified as an existing stepping-stone corridor, thus it has no minimal width. This corridor takes advantage of the numerous existing vegetated patches that would be currently providing movement opportunities for a number of mobile fauna species. This corridor is a highly visible, partly internal corridor that travels along the eastern side (Area G) of the Study Area. Importantly, this corridor would provide movement opportunities for fauna species recolonising the post-mining landscape from the north. This corridor contains a considerable amount of 'stepping stone' fragments, and it would require relatively small areas of revegetation to greatly increase its value as a corridor.

A potential constraint for this option is the presence of the infrastructure corridor (which will contain a conveyor), which will form the southern boundary to the corridor and may create a partial barrier to fauna movement to the south. While the direct disturbance corridor for the conveyor is likely to be no more than 30 metres wide, the noise and dust from the conveyor has the potential to deter egress of some of the more sensitive fauna species. For this reason, this corridor does not continue further to the south of the infrastructure corridor, rather provides refuge habitat along the eastern boundary of the Study Area.

The total area for this corridor is 223 hectares, of which 119 hectares are currently vegetated (**Table 9.8**). It will therefore require 104 hectares (47%) of the corridor to be revegetated. No part of this corridor option is currently under Centennial ownership, or is under Agreement with Centennial.

Table 9.8 – Existing Vegetation

Vegetation Community	Formation	Area (ha)
Slaty Box Woodland	Woodland	26
Ironbark Woodland Complex	Woodland	93
Total		**119**

Corridor Option 6 contains existing vegetation that forms part of the Slaty Box and Ironbark Woodland vegetation communities. Appropriate species composition for revegetation for this corridor will be dominated by species recorded from these vegetation communities.

Corridor Option 7 – Southern Proposed Offset Areas to Myambat Military Area

Corridor Option 7 is a potential regional corridor with a minimum width of 1000 metres. This external option is designed to make best use of a large area of 'stepping stone' habitat that currently connects the southern Proposed Offset Areas (Area A) to the large vegetated remnant north of Myambat Military Area, which is potentially the most secure of all of the large vegetation remnants to which the Study Area could be directly connected to. This remnant is currently managed in part for conservation purposes by the Department of Defence, and is the most ecologically similar to the Study Area of all the nearby remnants. This corridor could potentially be wide and have a low edge area. Any revegetation works in this corridor would help to buffer the adjoining southern Proposed Offset Areas.

The relatively uniform existing vegetation within this corridor will limit the potential for floristic and structural diversity, however this is not likely to be a major hindrance to the functioning of the corridor.

The total area for this corridor is 209 hectares, of which 105 hectares are currently vegetated (**Table 9.9**). It would therefore require 104 hectares (50%) of the corridor to be revegetated. None of the properties within this option are currently owned or under agreement with Centennial.

Table 9.9 – Existing Vegetation

Vegetation Community	Formation	Area (ha)
Paperbark Woodland	Woodland	0.2
Slaty Box Woodland	Woodland	78.2
Ironbark Woodland Complex	Woodland	0.2
Total		**78.6**

Corridor Option 7 contains existing vegetation that forms part of the Paperbark Woodland, Ironbark Woodland Complex and Slaty Box Woodland. Appropriate species composition for revegetation for this Corridor will be dominated by species recorded from these vegetation communities.

Corridor Option 8 – Southern Proposed Offset Areas to Manobalai Crown Land

Corridor Option 8 is an external corridor that provides an access/egress route for the Study Area, particularly providing connectivity between the southern Proposed Offset Areas (Area A) and Manobalai Crown Land to the west. This is a potential regional corridor, thus would be at least 1000 metres wide. This is a highly visible, external corridor that would provide an egress route to highly secure lands in front of the advancing mine. Although the presence of Wybong Creek within this corridor might be a minor barrier to the movement of some fauna groups, it would also provide for increased water availability, and for the potential establishment of river-flat communities such as Forest Red Gum Woodland, River Red Gum Woodland or Weeping Myall Woodland. The increased width of this corridor would also reduce edge: area ratio effects.

The establishment of this corridor will be challenged by the small number of 'stepping stone' remnants that would aid in revegetation, as well as the large area requiring revegetation and the potential barrier of Wybong Road.

The total area for this corridor is 291 hectares, of which 120 hectares are currently vegetated (**Table 9.10**). It will therefore require 171 hectares (59%) of the corridor to be revegetated. 45% of this corridor option is currently under Centennial ownership, or is under Agreement with Centennial.

Table 9.10 – Existing Vegetation

Vegetation Community	Formation	Area (ha)
Salty Box Woodland	Woodland	47
Ironbark Woodland Complex	Woodland	24
Sheltered Grey Gum Woodland	Woodland	0.1
Ironbark-Wattle Low Exposed Woodland Complex	Woodland	26
Tall Mixed Shrubland Complex	Shrubland	12
Coast Myall Exposed Woodland	Shrubland	10
Total		**119.1**

Corridor Option 8 contains existing vegetation that forms part of the Slaty Box Woodland, Ironbark Woodland Complex, Sheltered Grey Gum Woodland, Ironbark-Wattle Low Exposed Woodland Complex, Tall Mixed Shrubland Complex and Coast Myall Exposed Woodland vegetation communities. Appropriate species composition for revegetation for this Corridor will be dominated by species recorded from these vegetation communities. The presence of Wybong Creek within this corridor would allow for further riparian and valley floor vegetation communities to be established.

9.5.4.4 Preferred Corridor Strategy

A total of eight options have been considered as part of development of the conceptual corridor strategy. Each option has been designed to provide the maximum ecological function to the Study Area by protecting and enhancing existing movement opportunities for flora and fauna species (corridor options 1, 3, 4, 5 and 7), as well as providing alternate options within and outside of the Study Area (corridor options 2 and 8). Where possible, options have made best use of existing vegetation, thus reducing the potential time lag in corridor function created by the need for revegetation.

In general, the desired ecological function for the corridor options is to provide vegetated connectivity to/from the north, as well as to/from the west. These routes contain the largest amounts of high-quality conserved habitat in the vicinity of the Study Area, thus should be the main targets for connectivity through these options. The nature of the vegetation of the Study Area allows for the choice between Corridor Options 5 and 4 to provide the northern connectivity, and for Corridor Options 2 and 8 to provide the western connectivity.

As Corridor Options 1 and 3 are essentially located within the Study Area, these will essentially be established as part of the Biodiversity Offset Strategy. Their contribution to internal movement opportunities within the Study Area throughout the life of the mine will be essential.

Connectivity to the south would also be a desirable option to provide for movement flow in a north/south direction. This option is catered for by Corridor Option 7, which is proposed to be retained as a stepping-stone corridor, as this area is currently well-vegetated with existing fragments that are already likely to be facilitating movement for a number of faunal groups. When considering the other options in this strategy, it is likely that this option could be developed into a valuable regional corridor with a comparatively low level of revegetation effort.

The potential contribution of Corridor Option 6 is also noteworthy. This is a suitable candidate for the stepping-stone corridors, and is likely to be functioning as such currently. This option would require little revegetation effort to greatly increase its functioning, and would provide the only formal eastern movement opportunities for the Project.

9.5.4.5 Conclusion to Corridor Strategy

A total of eight corridor options have been considered as part of the corridor strategy. These include two options each to provide for northern and western connectivity and movement opportunities. Of these, Corridor Options 5 and 8 are preferred from an ecological perspective as they link large amounts of Crown land to the Study Area. When a northern and a western corridor are combined with the internal Options 1 and 3, this strategy will provide for internal connectivity within the Study Area, and for external access/egress to large areas of high quality habitat to the north and west. This strategy will be augmented with the existing stepping-stone functions of Option 6 for connectivity along the eastern side of the Study Area and the existing function of Option 7 for southern connectivity to protect and enhance movement opportunities for flora and fauna species into and out of the Study Area.

9.5.5 Wybong Uplands Land Management Strategy

Centennial proposes to establish a land management strategy which will achieve its corporate sustainability goals. The Strategy “Wybong Uplands Land Management Strategy” (WULMS) will target sustainable land management across the broader landscape of the Wybong area and will not be limited to the Study Area. Land management within the Proposed Disturbance Area will complement the Strategy. The Strategy will be managed by a committee, the structure of which is yet to be determined. The committee is proposed to include members from the community, Centennial, relevant land management groups and/or agencies.

The aim of the Strategy is long term sustainable land management within the Wybong area. Actions to achieve this aim may include:

- Dryland salinity mitigation;
- Drought proof farming;
- Sustainable agriculture;

- Demonstration farms;
- Riparian zone management; and
- Ecological corridors.

Centennial will commit to funding for the Strategy of $100,000 per year for 5 years. WULMS may seek further funding through government environmental grants.

Amongst other objectives, it is expected that the WULMS strategy will be used to work with landholders in the area of Corridor Option 7 in an endeavour to achieve ecological corridor outcomes in the area. Any works proposed within this area as part of the WULMS strategy will complement works completed for ecological corridors within the Study Area.

9.5.6 Habitat Augmentation Strategy

The augmentation of existing vegetation within the Proposed Offset Areas will contribute greatly to increasing the quality of habitat for threatened species in this area. Augmentation strategies will also be applied to corridors and other areas of revegetation or regeneration. Habitat augmentation can be achieved in a number of ways, however in this case it will focus on the provision of specific habitat features for key threatened species. The aim of doing so will be to increase to a high level the specific habitat features for key threatened species, thereby improving the quality of the habitat so it is able to support greater numbers of those species. Specific habitat features are those that can be a limiting factor to population thresholds, and will include habitat features such as tree hollows and specific foraging resources.

The habitat augmentation strategy will target areas of existing vegetation within the Proposed Offset Areas to increase its habitat value, as well as areas of revegetation and regeneration within the corridors or post-mining rehabilitation. This strategy will involve activities such as:

- Installation of nest boxes;
- Salvage and re-erection of hollows;
- Salvage and replacement of habitat features such as hollow logs, fallen timber and boulders; and
- Planting of specific habitat resources within existing vegetation to increase the quality of habitat.

Each activity is discussed in further detail in the following sections.

9.5.6.1 Nest Boxes

One of the identified key ecological impacts of the Project will be the removal of habitat features that are critical to the persistence of a species in a particular area, such as tree hollows. The availability of suitable hollows within a landscape is a recognised limiting factor to the survival of hollow-dependent species (DEC 2004). In particular, the loss of suitable hollows is a major factor contributing to the listing of many threatened species as Vulnerable or Endangered under the State and Commonwealth of threatened species legislation.

The results from the condition assessment indicate that hollows of various sizes are present across the Study Area, in variable densities.

The nest box strategy is designed to aim for no net loss of hollows within the Study Area. To achieve this, nest boxes will be placed in the Proposed Offset Areas and any areas subject to revegetation or regeneration, particularly corridors and previously mined areas, as soon as the vegetation is suitably established.

To ensure the success of the nest box establishment program, the following approach is proposed for nest box design and erection:

- nest boxes will be appropriately designed for targeted threatened species;
- all nest boxes will be constructed out of marine grade plywood or other similar suitable material;
- a variety of nest box designs will be provided;
- nest boxes will be appropriately positioned within the landscape and within trees;
- all nest boxes will be subject to appropriate, regular maintenance of their structural integrity and attachment; and
- all nest boxes will be regularly monitored for fauna contents (and cleared if feral species present) and effectiveness in meeting their purpose.

Quantifying the requirement for nest box provision will be based on the results of the condition assessment, where average densities of hollows of each size class were recorded within each survey plot.

The known densities of hollows for vegetation formations within the Proposed Disturbance Area will need to be replicated within the Proposed Offset Areas (to add to existing hollow densities) and within areas of rehabilitation and regeneration. This will require the establishment of substantial nest boxes in the Proposed Offset Areas.

Once the revegetation and regeneration areas contain trees of suitable age, nest boxes will be added in densities representative of the relevant vegetation formation and location. A range of hollow size classes will be provided for within the revegetated area, thus increasing the quality of habitat for key threatened species.

9.5.6.2 Hollow Salvage

While nest boxes are an acceptable method of providing nesting and roosting habitat for hollow-dependent species, reasonable efforts will be made to salvage existing hollows during the clearance of the Proposed Disturbance Area. This approach will be used to ensure optimal re-use of existing resources within the Proposed Disturbance Area, and combined with nest box establishment will ensure no net loss of nesting or roosting habitat within the Study Area.

Pre-clearance surveys will be used to clearly mark hollow-bearing trees. Hollow salvage operations will then be incorporated into the clearing phase, and will involve the careful removal of identified hollows, completion of capping and any other restorative works required, then re-erection of the hollows in suitable positions within the Proposed Offset Areas, areas of revegetation for corridors or habitat augmentation.

Salvaged and re-erected hollows will be subject to the same levels of maintenance and monitoring as nest boxes.

9.5.6.3 Replacement of other Specific Habitat Features

A number of threatened species identified within the Study Area have specific habitat features (excluding tree hollows discussed above) that are required to provide adequate foraging, roosting or breeding habitat. Examples of specific habitat features include, but are not limited to:

- Hollow logs and fallen timber for the spotted-tailed quoll (*Dasyurus maculatus maculatus*);
- Fallen timber and stumps to provide perch sites for the hooded robin (*Melanodryas cucullata cucullata*);
- Shrubby acacia understorey for the squirrel glider (*Petaurus norfolcensis*); and
- Dams with fringing vegetation for the large-footed myotis (*Myotis adversus*).

The provision of adequate levels of such specific habitat features will greatly enhance the quality of habitat for such key threatened species. In particular, where habitat is deemed marginal for a key threatened species, the provision of certain specific habitat features may increase the potential for such species to move in from adjoining areas to become resident.

The Project will remove a number of specific habitat features for key threatened species, including:

- Tree hollows of varying sizes;
- Hollow logs;
- Fallen timber;
- Boulders or rocky areas;
- Dams; and
- Specific foraging resources such as acacias and allocasuarinas.

The salvage and relocation of hollows, hollow logs, fallen timber and boulders should be attempted wherever possible. Such features can be selectively erected within the Proposed Offset Areas, where these resources have been identified as being scarce, or they can be placed within revegetated and regenerated areas (such as corridors) to increase habitat complexity and to increase the quality of such areas for key threatened species. In such cases, specific habitat features can be identified during pre-clearing surveys, and can be replaced in designated areas.

While dams will be removed from within the Proposed Disturbance Area, the creation of 13 sedimentation dams and two large water storage dams during various stages of the Project will significantly increase the foraging value for the large-footed myotis. It is proposed that these dams will be constructed so that suitable foraging habitat is provided for the large-footed myotis. The thirteen sedimentation dams (with surface areas ranging between 0.1 and 1.4 hectares) will be constructed as part of the water management plan, and will be staged over the 20 year life of the mine. A large 46 hectare (surface area) dam will be constructed to be the main water storage dam for the Project and will be operational for the life of the mine. Between years 7 and 15, a 6.9 hectare dam on Anvil Creek will prevent Anvil Creek runoff from entering the Main Pit.

Assuming all existing farm dams in the Proposed Disturbance Area will be removed during the Project, the creation of the above dams over the life of the mine will substantially increase the foraging values for the large-footed myotis.

There is the potential that at the end of the mine the removal of the two large dams may impact on the local population that may have increased in size due to the availability of additional foraging habitat. This is not expected to put this species at threat. The end of the mine will see the establishment of a similar level of foraging value for the large-footed myotis in the post-mining Proposed Disturbance Area as that prior to the start of the mine.

Supplementary planting of specific habitat species within particular areas will also be used to increase the quality of habitat for target threatened species. For example, the supplementary planting of identified areas with *Allocasuarina verticillata* will increase the known foraging habitat for the glossy black-cockatoo (*Calyptorhynchus lathami*). For species with such specific foraging requirements, supplementary planting of foraging resources has the potential to greatly increase the quality of habitat, thus contributing to the amelioration of the loss of known foraging habitat within the Proposed Disturbance Area.

Similarly, the supplementary planting of identified areas with specific acacia species will increase the potential foraging habitat for the squirrel glider. This too, would contribute to ameliorating the impact of the proposal on this species.

9.5.7 Aquatic Strategy

The drainage line to be constructed as part of the final landform where Anvil Creek now exists will be designed and constructed to provide a stable channel with a natural appearance that blends in with any adjoining riparian areas. Native trees and shrubs will be planted along the drainage alignment to enhance the long term stability of the drainage system and to provide suitable habitat for native fauna.

Sedimentation and other dams will be designed to allow for the establishment of aquatic sedge and rush vegetation around the perimeter. Habitat re-creation initiatives are detailed in **Section 9.4.4**.

During mining, the provision of adequately designed water management structures, that is dams with shallow verges allowing the colonisation of aquatic macrophytes and sedges, will ensure that habitat for the range of macroinvertebrate species recorded during the aquatic survey will remain within the Proposed Disturbance Area.

9.6 Conclusion and Assessment of Net Impacts

As a result of the modifications made during mine planning, the Standard Impact Mitigation Strategies and the Biodiversity Offset Strategy, it is considered likely that there will be no significant impact on threatened species, populations, endangered ecological communities, or their habitats, and no net loss of flora and fauna values, over the medium to long term as a result of the Project.

10.0 Ecological Monitoring Program and Completion Criteria

10.1 Ecological Monitoring Program

The aim of the ecological monitoring program will be to assess the adequacy of the Standard Impact Mitigation Strategy and the Biodiversity Offsets Strategy. This will require the design and implementation of a rigorous and systematic monitoring program that includes a positive feedback loop, to allow for the adaptive management of all aspects of the monitoring program.

This Section provides details on the monitoring program, including the general types of monitoring to be completed, the aims of this monitoring and the types of data the monitoring will collect. Specific details on the monitoring program will be provided within a comprehensive Ecological Management Plan, to be completed prior to commencement of clearing on the site. This document will contain specific requirements for the monitoring program, including methods to be used, monitoring frequencies and locations.

The aims of the ecological monitoring program will be to:

- document changes in retained vegetation within the Proposed Offset Areas and corridors, through comparison with baseline data and comparison with predictions in the EA;

- document changes in the structure, composition and condition of revegetation or regeneration areas, through comparison with baseline data and control sites;

- determine if the impacts on key threatened species are consistent with predictions in the EA; and

- assess progressive changes to flora and fauna species assemblages within the Proposed Disturbance Area, and Proposed Offset Areas as the mine progresses.

Ecological monitoring will be completed across the Study Area, and will include the following components:

- establishment of permanent monitoring plots and photo monitoring points in representative parts of the Study Area, including: retained vegetation of the Proposed Offset Areas, corridors and pre-mining Proposed Disturbance Area; and revegetated or regenerated areas within the offset areas and post-mining Proposed Disturbance Area;

- regular collection of systematic data from permanent monitoring plots;

- assessment of species diversity and abundance;

- assessment of habitat losses or gains;

- incidence of weeds and feral animals;

- factors that impact on biodiversity;

- the security of protected areas;

- the ongoing revegetation and regeneration of vegetation communities;

- the resilience of ecosystems; and
- landscape function analysis to assess the biogeochemical functioning of the landscape in rehabilitated areas, through comparison with control sites.

Monitoring for flora and fauna species may need to be undertaken at different times, depending on the optimal detection period for each target species or group.

The ecological monitoring program will involve the monitoring of retained vegetation, revegetation and regeneration, fauna species and their habitat, key threatened species and aquatic habitat. Each of these are discussed further in the following sections.

The location and establishment of monitoring sites will be undertaken by suitably qualified and experienced ecologists. The monitoring process will be documented in an annual report that will provide details of the flora and fauna species and ecological communities present at each monitoring site, identify the impact of the proposal over time and, as appropriate, provide ameliorative methods and management recommendations in order to optimise the ecological diversity of the Study Area.

10.1.1 Monitoring of Retained Vegetation

Monitoring of retained vegetation will be undertaken on an annual basis. The condition of retained vegetation within the Proposed Offset Areas and corridors will be monitored to identify any deterioration or improvement in habitat quality. The monitoring surveys will assess and systematically record the following vegetation characteristics:

- floristic composition and structure;
- general health of vegetation;
- evidence of natural regeneration;
- occurrence and abundance of weed species;
- signs of disturbance, either by stock or humans;
- evidence of feral animals; and
- any observable impacts of the operations, such as the effectiveness of sediment and erosion control structures.

The monitoring approach will undertake systematic and repeatable surveys at permanent monitoring plots. Each vegetation community will be appropriately sampled and monitored annually in the same season (for example, spring or summer or autumn).

Permanent monitoring plots will consist of quadrats, which will be sampled in order to record species diversity and structural composition of the vegetation at each monitoring plot. Plots will be sampled using systematic, repeatable techniques, such as the Modified Braun-Blanquet Cover-abundance method, to ensure the data collected are comparable from year to year and are as little affected by observer bias as possible. This will allow a comparison of flora species diversity and abundance over time. Photo monitoring points will also be established within each of the permanent monitoring plots.

Monitoring plots will also be established within the pre-mining vegetation of the Proposed Disturbance Area, to assess the progressive impacts of the mine on adjoining vegetation.

The monitoring points will be selected and surveyed during the first year of the Project. This information will form the baseline data for comparison with future results. Subsequent monitoring will be undertaken annually, with the monitoring frequency to be assessed on an ongoing basis.

10.1.2 Monitoring of Revegetation and Regeneration Areas

The monitoring of areas of revegetation and regeneration will be undertaken three months after planting, followed by six months, and then twelve months and annually thereafter, until the relevant completion criteria have been met (refer to **Section 10.2**). The monitoring will identify any areas of land degradation and will allow for the identification of priority areas for remediation and rehabilitation. Monitoring plots will be established within areas of revegetation and regeneration, within the post-mining Proposed Disturbance Area and within the Proposed Offset Areas.

Permanent monitoring plots will consist of quadrats which will be established in post-mining revegetation and regeneration areas. These will be re-sampled annually, and the resulting data will be compared to previous results to identify changes to the vegetation between each monitoring period. The locations of the plots will be determined following the commencement of revegetation and regeneration, and additional plots will be added to the monitoring program as rehabilitation progresses.

The results from this monitoring will provide a comparison of flora species and abundance over time and will be used to determine whether the rehabilitation has achieved its objective of creating self-sustaining native vegetation communities.

Monitoring of any revegetated areas will include an assessment of the following features:

- general impressions on revegetation germination rates;
- plant health;
- feral animals and the need for control measures;
- weed infestation and the need for control measures;
- requirements for additional planting to be undertaken;
- need for further application of soil improver;
- erosion and the need for repair of eroded areas;
- fire management;
- quality, effectiveness and need for protection;
- signs of disturbance, either by animals or humans; and
- success of any management programs implemented following previous monitoring inspections.

Monitoring results will be assessed and utilised in the continual improvement and refinement of rehabilitation techniques and will be documented as part of the annual environmental reporting.

Weed and vermin control will be conducted regularly, and will include:

- regular site inspections to identify areas of weed infestation and type of weed species;
- the use of weed transportation controls to reduce the chance of movement of weeds by vehicles;
- development and implementation of an eradication plan applicable to the circumstances, which may include manual removal, spot spraying, boom spraying, aerial spraying or biological control;
- minimisation of vegetation disturbance by minimising the number of tracks;
- minimisation of clearing and other disturbance of vegetation associated with civil works;
- early establishment and maintenance of vigorous grasses and native trees particularly during rehabilitation of overburden dumps; and
- management of topsoil stockpiles to control weeds.

10.1.3 Fauna Monitoring

Initial fauna monitoring will be undertaken in the Proposed Offset Areas and within the pre-mining vegetation of the Proposed Disturbance Area. This data will be used to build on existing baseline information from which to compare post-mining results. As parts of the Proposed Disturbance Area will not be subject to direct disturbance for a number of years, some further baseline monitoring should be completed within such areas to provide data on the tolerance levels of key threatened species within a mining landscape. Additional fauna monitoring sites will be established within the revegetation and regeneration areas when these areas are deemed mature enough to support reasonable fauna assemblages. This strategy will allow a comparison between the fauna utilisation of retained, mature fauna habitats and revegetation and regeneration areas at a range of age classes.

At each of the proposed monitoring points, a range of fauna survey techniques will be employed to determine ongoing fauna use of habitat within the Study Area, particularly focussing on the presence of key threatened species. It is proposed that monitoring of fauna be undertaken annually, consistent with retained vegetation monitoring. The types of surveys that will be required to undertake adequate monitoring of fauna may include spotlighting, herpetological surveys, diurnal and nocturnal bird surveys, Anabat echolocation call detection, and the use of hair funnels to detect terrestrial and arboreal mammals. Fauna surveys will specifically target threatened species previously recorded, or with potential to occur within the area. The results of the monitoring will be analysed and compared to previous survey results to determine general trends and as necessary, appropriate amelioration measures will be recommended.

10.1.3.1 Nest Box Monitoring

Nest box monitoring will be undertaken annually after the first phase of nest box installation to record their effectiveness. This monitoring will continue for the life of the mine and will report on the degree of use of nest boxes and make recommendations regarding maintenance activities as required. The need and frequency of this monitoring program will be assessed periodically.

Monitoring will be undertaken during spring each year, where possible, when the use of boxes by bird species can be detected. While mammal species will den in the nest boxes all year, bird species such as parrots using the boxes solely for breeding will only be present for 8 to 12 weeks during early spring to late spring.

All nest box monitoring will be undertaken by qualified ecologists with the results included in the annual monitoring report.

Nest box condition monitoring will be undertaken for the life of the mine to ensure that there is no loss of boxes through deterioration over time. Replacement boxes will be installed to ensure that there is no net loss of nest boxes.

10.1.4 Threatened Species Monitoring

Due to the large number of threatened flora and fauna species identified within the Study Area, a detailed threatened species monitoring program will be required. Such monitoring will take the form of annual monitoring of the presence or absence of threatened species previously recorded within the Study Area. The results of the monitoring will be analysed and compared to previous monitoring results to determine trends and refine amelioration measures, as required.

Threatened species monitoring will involve detailed survey methods designed to target threatened flora and fauna species previously identified within the Study Area. Monitoring works will be completed within the Proposed Disturbance Area and Proposed Offset Areas, as well as within revegetated areas and corridors, once the vegetation reaches an appropriate age, generally at least five years. A number of fixed monitoring points will be established and revisited every year to provide progressive comparisons.

The results of the threatened species monitoring will be reported in the annual environmental reporting. The results of the monitoring will be reviewed annually and the timing, placement and requirements of the monitoring will be reviewed every year.

If further threatened species, or significant new records of existing threatened species, are collected, the significance of such records will be reviewed, in addition to any options for minimising impacts on these species. The review will also consider whether monitoring should be expanded or modified in response to the new information.

10.1.5 Aquatic Monitoring

There is the opportunity to incorporate the enhancement of aquatic habitat into the construction of drainage channels in the final landform and in management of Proposed Offset Areas. This is discussed in **Section 9.2.4**. The following aquatic monitoring will be incorporated into the overall ecological monitoring program, as appropriate for specific drainage lines:

- general health of the aquatic vegetation;
- occurrence and abundance of weed species;
- signs of disturbance;
- any observable impacts of mining such as the effectiveness (or otherwise) of sediment and erosion control structures;

- the habitat attributes of the aquatic vegetation;
- the presence of fauna species utilising the habitat, particularly amphibians; and
- the presence and type of macroinvertebrates utilising the recreated habitats.

10.1.6 Landscape Function Analysis

Landscape function analysis (LFA) is a monitoring procedure that uses rapidly acquired field-assessed indicators to assess the biogeochemical functioning of landscapes (Tongway & Hindley 2004). LFA is based mainly on processes involved in surface hydrology: rainfall, infiltration, runoff, erosion, plant growth and nutrient cycling. It comprises four components (Tongway & Hindley 2004):

- a conceptual framework;
- field data acquisition;
- data reduction and tabulation; and
- an interpretational framework

LFA will be undertaken as part of the monitoring program. It will be completed at each of the revegetation and regeneration permanent plots, as well as in appropriate benchmark retained vegetation monitoring plots.

As part of this analysis, the following features will be recorded:

- Rainsplash protection;
- Perennial vegetation cover;
- Litter;
- Cryptogam cover;
- Crust brokenness;
- Soil erosion type and severity;
- Deposited materials;
- Soil surface roughness;
- Surface nature (resistance to disturbance);
- Slake test; and
- Texture.

The information gathered from LFA monitoring will enable a detailed assessment of the success or otherwise of the establishment of appropriately functioning ecosystems, and will guide future re-establishment techniques.

10.2 Completion Criteria

10.2.1 Objectives of Completion Criteria

A detailed set of completion criteria will be developed in order to provide an assessment framework for the success of the proposed ecological management. These criteria will relate to the objectives of the retention of existing vegetation, revegetation and regeneration activities, fauna habitat, habitat augmentation and landscape function analysis.

The following considerations (as per Nichols 2004) were considered when developing a conceptual set of completion criteria for the Project:

- The criteria will include prescriptive criteria (confirming that identified actions have been completed) and performance criteria (confirming that rehabilitation has achieved a particular standard);
- The criteria will be divided into appropriate stages of the mining operation;
- The development of criteria, standards and milestones will be an iterative process, with the criteria revised according to what is demonstrated to be achievable through monitoring and research;
- Centennial will consult with identified stakeholders during the development of agreed completion criteria;
- When finalised, completion criteria will function as 'trigger levels'. Failure to meet these criteria will 'trigger' an internal investigation into the likely causes; and
- Completion criteria, standards and milestones will be reviewed every five years and, where necessary, revised by agreement between the mine and the regulatory authority, to take account of significant advances in cost-effective rehabilitation techniques.

10.2.2 Conceptual Completion Criteria

Table 10.1 contains a set of conceptual completion criteria relative to the Project. These criteria are relevant to the various components of the impact mitigation strategies, and detail the goals which must be achieved prior to these strategies being deemed a success. These criteria will be refined in consultation with relevant agencies. It is expected that attainment of all of these completion criteria will signify the achievement off the overall goal of no net loss of flora and fauna values in the Project area in the medium to long term.

Table 10.1 – Conceptual Ecological Completion Criteria for Impact Mitigation Strategies

Impact Mitigation Strategy	Completion Criteria
Revegetation and Regeneration Areas	• The area of revegetated and regenerated vegetation is equal to or greater than the pre-mining extent
	• Revegetation and regeneration areas will be progressing toward self-sustaining indigenous vegetation communities
	• The revegetated and regenerated vegetation communities will comprise appropriate representations of existing vegetation communities (where considered desirable) in similar proportions to the pre-mining extent, or to other agreed target levels

Table 10.1 – Conceptual Ecological Completion Criteria for Impact Mitigation Strategies (cont)

Impact Mitigation Strategy	Completion Criteria
Revegetation and Regeneration Areas (cont)	• There are no significant weed infestations and weeds do not comprise a significant proportion of the species in any stratum
	• Revegetated and regenerated vegetation communities provide habitat for a suite of fauna species similar to the pre-mining fauna communities.
	• Revegetation and regeneration areas will contain flora species assemblages characteristic of the desired native vegetation community
Retained Vegetation	• Retained vegetation is managed to improve condition and existing flora and fauna habitat values
	• There are no significant weed infestations and weeds do not comprise a significant proportion of the species in any stratum
Ecological Corridors	• Ecological corridors are shown to be successfully established and consistent with desired vegetation community compositions. • Pest species (flora and fauna) are managed and controlled (where possible) within ecological corridors. • Presence/absence monitoring of flora and fauna species identify increasing levels of corridor function in terms of species movement.
Native Flora Species Assemblages	• Ecological monitoring identifies no loss of native flora species diversity within areas of retained vegetation
	• Any identified increases in exotic flora species are addressed as part of the Ecological Management Plan.
Native Fauna Species Assemblages	• Ecological monitoring identifies no loss of native fauna species diversity within areas of retained vegetation
Pest Species Management	• Management procedures are developed, and acted upon in order to manage and control (where possible) pest flora and fauna species.
	• Any identified increases in weeds are addressed as part of the Ecological Management Plan.
Habitat Augmentation	• Nest boxes will be maintained in suitable abundance, position and condition throughout the life of the mine, and beyond.
	• Monitoring of nest boxes identifies usage by target native species.
Landscape Function Analysis	• Results of ongoing landscape function analysis identifies the final landform is returning to a suitable pre-mining function.

The level of progress with satisfaction of these completion criteria will be assessed after the completion of each monitoring period. It may be necessary to periodically review these completion criteria in order to accommodate the inclusion of monitoring data, particularly where new ecological issues are identified. The gradual achievement (or otherwise) of these completion criteria will be assessed and discussed in the annual documentation of monitoring results, which will include the identification of any failures of the criteria, and measures of addressing any such issue.

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NSW Scientific Committee (2001b) Final Determination – Speckled Warbler – Vulnerable Species Listing.

NSW Scientific Committee (2001c) Final Determination – Hooded Robin – Vulnerable Species Listing.

NSW Scientific Committee (2001d) Final Determination – Black-chinned Honeyeater – Vulnerable Species Listing.

NSW Scientific Committee (2001e) Final Determination – Grey-crowned Babbler – Vulnerable Species Listing.

NSW Scientific Committee (2001f) Final Determination – Diamond Firetail – Vulnerable Species Listing.

NSW Scientific Committee (2001g) Final Determination – Squirrel Glider – Vulnerable Species Listing.

NSW Scientific Committee (2001h) Final Determination – grey-headed flying fox – Vulnerable Species Listing.

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NSW Scientific Committee (2002d) *Ecological Consequences of High Frequency Fires - Key Threatening Process Declaration: NSW Scientific Committee Final Determination*.

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NSW Scientific Committee (2005c) Final Determination - Red-backed Button-quail – vulnerable species listing.

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NSW Scientific Committee (2005h) *Invasion of the Yellow Crazy Ant* - *Key Threatening Process Declaration: NSW Scientific Committee Final Determination*.

NSW Scientific Committee (2006a) *Cane Toad - Key Threatening Process Declaration: NSW Scientific Committee Final Determination*.

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APPENDIX A

Potential Threatened Species

Potential Threatened Species

The following abbreviation or symbols are used to identify the abbreviations used in the table below:

TSC Act	*Threatened Species Conservation Act* 1995 (TSC Act);
EPBC Act	*Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act);
ROTAP	Rare or Threatened Australian Plant (as per Briggs & Leigh 1996);
DEC	Department of Environment and Conservation;
DEH	Department of Environment and Heritage;
✓	Species record;
E	Endangered;
V	Vulnerable;
PD	Preliminary Determination;
EEC	Endangered Ecological Community;
EP	Endangered Population;
MAR	Listed marine species under the EPBC Act;
MIG	Listed migratory species under the EPBC Act;
Rec	Recommended by a recognised author; and
U	Unconfirmed.

Bold type denotes a threatened species recorded from the Study Area.

Reports used as part of Literature Review (full references provided in Section 11 of report):

a	Land & Environment Planning (1999);
b	Bell (1997);
c	Peake (2006);
d	NPWS (2001);
e	Hill (2000); and
f	HLA (2002).

Species Name		Record Source															
Scientific Name	**Common Name**	**ROTAP**	**TSC Act**	**EPBC Act**	**DEC Web Muswellbrook Sheet (Feb 2006)**	**DEC Atlas Muswellbrook Sheet 20km (Feb 06)**	**DEC Atlas Unique (Jan 06)**	**DEH Protected Matters Search Tool 20km (Jan 06)**	**Recorded in Proposed Disturbance Area (Umwelt & HLA)**	**Recorded in Proposed Offset Area (Umwelt & HLA)**	**Abel Ecology (2005)**	**Literature Review**	**Birds Australia (Feb 2006)**	**Australian Museum (Feb 2006)**	**National Herbarium of NSW (Feb 2006)**	**Potential based on professional opinion**	**DEC Preliminary DGRs (June 2005)**
Fauna																	
Leipoa ocellata	malleefowl		E	V MIG				✓				d (U)					
Stictonetta naevosa	freckled duck		V		✓	✓	✓						✓				
Ardea alba	great egret			MAR				✓					✓				
Ardea ibis	cattle egret			MAR				✓					✓				
Pandion haliaetus	osprey		V								✓						
Lophoictinia isura	square-tailed kite		V			✓	✓				✓	d					✓
Haliaeetus leucogaster	**white-bellied sea-eagle**			**MAR**				✓	✓			**d**					
Erythrotriorchis radiatus	red goshawk		E	V		✓	✓										
Falco hypoleucos	grey falcon		V										✓				
Turnix maculosa	red-backed button-quail		V														
Gallinago hardwickii	Japanese snipe			MAR				✓									
Tringa nebularia	common greenshank			MIG									✓				
Rostratula benghalensis australis	Australian painted snipe		E	V				✓									
Rostratula benghalensis s. lat.	painted snipe		E	V MIG				✓									
Burhinus grallarius	bush stone-curlew		E		✓	✓	✓										
Calyptorhynchus banksii graptogyne	red-tailed black cockatoo		V	E												✓	
Calyptorhynchus lathami	**glossy black-cockatoo**		**V**		✓	✓	✓		✓	✓	✓	**a,d, f**					
Callocephalon fimbriatum	gang gang cockatoo		V		✓	✓	✓					d	✓				
Polytelis swainsonii	superb parrot		V	V				✓									

Species Name		Record Source															
Scientific Name	**Common Name**	**ROTAP**	**TSC Act**	**EPBC Act**	**DEC Web Muswellbrook Sheet (Feb 2006)**	**DEC Atlas Muswellbrook Sheet 20km (Feb 06)**	**DEC Atlas Unique (Jan 06)**	**DEH Protected Matters Search Tool 20km (Jan 06)**	**Recorded in Proposed Disturbance Area (Umwelt & HLA)**	**Recorded in Proposed Offset Area (Umwelt & HLA)**	**Abel Ecology (2005)**	**Literature Review**	**Birds Australia (Feb 2006)**	**Australian Museum (Feb 2006)**	**National Herbarium of NSW (Feb 2006)**	**Potential based on professional opinion**	**DEC Preliminary DGRs (June 2005)**
Lathamus discolor	swift parrot		E	E MAR	✓	✓	✓	✓									
Neophema pulchella	**turquoise parrot**		**V**		✓	✓	✓		✓		✓	**a,d**	✓				
Ninox strenua	**powerful owl**		**V**		✓	✓	✓				✓	**a,c, d**	✓				
Ninox connivens	barking owl		V		✓	✓	✓				✓	d					
Tyto tenebricosa	sooty owl		V		✓	✓	✓										
Tyto novaehollandiae	**masked owl**		**V**			✓	✓			✓	✓	**d**					
Hirundapus caudacutus	**white-throated needletail**			**MAR**				✓		✓			✓				
Apus pacificus	fork-tailed swift			MAR				✓									
Merops ornatus	**rainbow bee-eater**			**MAR**				✓	✓	✓			✓				
Climacteris picumnus victoriae	**brown treecreeper**		**V**		✓	✓	✓		✓	✓	✓	**a,d, f**	✓				✓
Pyrrholaemus sagittata	**speckled warbler**		**V**		✓	✓	✓		✓	✓	✓	**a,f**	✓				
Xanthomyza phrygia	regent honeyeater		E	E MIG	✓	✓	✓	✓				d	✓				
Melithreptus gularis gularis	black-chinned honeyeater		V		✓	✓	✓				✓	d					
Grantiella picta	painted honeyeater		V		✓	✓	✓				✓						
Melanodryas cucullata cucullata	**hooded robin**		**V**		✓	✓	✓		✓	✓	✓	**d,f**	✓				✓
Pomatostomus temporalis temporalis	**grey-crowned babbler**		**V**		✓	✓	✓		✓	✓	✓	**d,f**	✓				
Pachycephala olivacea	olive whistler		V									d					
Monarcha melanopsis	black-faced monarch			MAR				✓									
Myiagra cyanoleuca	**satin flycatcher**			**MAR**				✓	✓								
Coracina tenuirostris	cicadabird			MIG									✓				
Stagonopleura guttata	**diamond firetail**		**V**		✓	✓	✓		✓	✓	✓	**d,f**	✓				

Species Name		Record Source																	
Scientific Name	Common Name	ROTAP	TSC Act	EPBC Act	DEC Web Muswellbrook Sheet (Feb 2006)	DEC Atlas Muswellbrook Sheet 20km (Feb 06)	DEC Atlas Unique (Jan 06)	DEH Protected Matters Search Tool 20km (Jan 06)	Recorded in Proposed Disturbance Area (Umwelt & HLA)	Recorded in Proposed Offset Area (Umwelt & HLA)	Abel Ecology (2005)	Literature Review	Birds Australia (Feb 2006)	Australian Museum (Feb 2006)	National Herbarium of NSW (Feb 2006)	Potential based on professional opinion	DEC Preliminary DGRs (June 2005)
Aprasia parapulchella	pink-tailed legless lizard		V	V								d				✓	
Varanus rosenbergi	Rosenberg's goanna		V													✓	
Hoplocephalus bitorquatus	pale-headed snake		V													✓	
Hoplocephalus bungaroides	broad-headed snake		E	V				✓									
Mixophyes iteratus	giant barred frog		E	E		✓	✓										
Litoria aurea	green and golden bell frog		E	V	✓	✓	✓										
Dasyurus maculatus maculatus	spotted-tailed quoll (SE mainland)		V	E	✓	✓	✓	✓						✓			
Phascogale tapotatfa	brush-tailed phascogale		V													✓	
Planigale maculata	common planigale		V													✓	
Phascolarctos cinereus	**koala**		**V**		✓	✓	✓			✓	✓						
Cercartetus nanus	eastern pygmy possum		V													✓	
Petaurus norfolcensis	**squirrel glider**		**V**						✓	✓		**a,d**					
Petrogale penicillata	**brush-tailed rock-wallaby**		**E**	**V**	✓	✓	✓	✓		✓	✓	**d**					
Pteropus poliocephalus	grey-headed flying-fox		V	V				✓									
Saccolaimus flaviventris	yellow-bellied sheathtail bat		V									a					
Mormopterus norfolkensis	**eastern freetail-bat**		**V**		✓	✓	✓			✓		**a**					
Miniopterus schreibersii oceanensis	**eastern bentwing-bat**		**V**		✓	✓	✓		✓	✓	✓	**a,d, f**		✓			
Nyctophilus timoriensis	greater long-eared bat		V	V	✓	✓	✓	✓				a,d					
Chalinolobus dwyeri	**large-eared pied bat**		**V**	**V**	✓	✓	✓	✓		✓		**a,d**					
Chalinolobus picatus	little pied bat		V													✓	

Species Name		Record Source															
Scientific Name	Common Name	ROTAP	TSC Act	EPBC Act	DEC Web Muswellbrook Sheet (Feb 2006)	DEC Atlas Muswellbrook Sheet 20km (Feb 06)	DEC Atlas Unique (Jan 06)	DEH Protected Matters Search Tool 20km (Jan 06)	Recorded in Proposed Disturbance Area (Umwelt & HLA)	Recorded in Proposed Offset Area (Umwelt & HLA)	Abel Ecology (2005)	Literature Review	Birds Australia (Feb 2006)	Australian Museum (Feb 2006)	National Herbarium of NSW (Feb 2006)	Potential based on professional opinion	DEC Preliminary DGRs (June 2005)
Falsistrellis tasmaniensis	**eastern false pipistrelle**		**V**							✓		**f**					
Myotis adversus	**large-footed myotis**		**V**						✓	✓		**a**					
Scoteanax rueppellii	**greater broad-nosed bat**		**V**		✓	✓	✓		✓			**f**					
Vespadelus troughtoni	eastern cave bat		V		✓	✓	✓		✓	✓		a,d					
Flora																	
Acacia bulgaensis	Bulga wattle	2RC-										b,c					
Acacia dangarensis		2RC-t	E									e			✓		
Acacia flocktoniae		2VC-	V	V								b					
***Acacia pendula* population**	**weeping myall**		**EP**						✓	✓		**c**					✓
Acianthus apprimus		2R									✓						
Boronia ledifolia															✓		
Boronia rubiginosa		2RCa										b,e			✓		
Bothriochloa biloba		3V		V								b,c					
Callistemon linearifolius		2RCi	V														✓
Commersonia rosea		**Rec. 2E**	**E**		✓	✓	✓			✓		**c**					
***Cymbidium canaliculatum* population**	**tiger orchid**		**EP**						✓	✓							
Cynanchum elegans	white-flowered wax plant	3ECi	E	E				✓				b			✓		
Digitaria porrecta	finger panic grass	3E	E	E				✓									

Species Name		Record Source															
Scientific Name	Common Name	ROTAP	TSC Act	EPBC Act	DEC Web Muswellbrook Sheet (Feb 2006)	DEC Atlas Muswellbrook Sheet 20km (Feb 06)	DEC Atlas Unique (Jan 06)	DEH Protected Matters Search Tool 20km (Jan 06)	Recorded in Proposed Disturbance Area (Umwelt & HLA)	Recorded in Proposed Offset Area (Umwelt & HLA)	Abel Ecology (2005)	Literature Review	Birds Australia (Feb 2006)	Australian Museum (Feb 2006)	National Herbarium of NSW (Feb 2006)	Potential based on professional opinion	DEC Preliminary DGRs (June 2005)
Diuris pedunculata	small smake orchid	2E	E	E	✓	✓	✓					b			✓		
Diuris tricolor	**painted diurus**	**3K**	**V**	**V**	✓	✓	✓	✓			✓				✓		
Eucalyptus aenea		Rec. 2RC										c,e			✓		
Eucalyptus camaldulensis population	river red gum		EP		✓	✓						c					✓
Eucalyptus glaucina	slaty red gum	3VCa	V	V													✓
Eucalyptus nicholii	New England peppermint				✓	✓	✓										
Eucalyptus pumila	Pokolbin mallee	2VCi	V	V	✓	✓	✓					b					
Gonocarpus longifolius		3RC-															
Goodenia macbarronii	**narrow goodenia**	**3VC-**	**V**	**V**	✓	✓	✓		✓	✓					✓		
Grevillea johnsonii		2RCi										b,e			✓		
Grevillea montana	**mountain grevillea**	**2KC-**								✓	✓	**a, b,c**			✓		
Grevillea parviflora subsp. *parviflora*			V	V													✓
Homoranthus cernuus		2RCa													✓		
Homoranthus darwinioides		3VCa	V	V				✓				b			✓		
Isotropis foliosa		3KC-	V (PD)									a, c			✓		
Kennedia retrorsa		2VCa	V	V	✓	✓	✓	✓				b, e			✓		
Lasiopetalum longistamineum		**2VC-**	**V**	**V**	✓	✓	✓	✓		✓		**b**			✓		

Species Name		Record Source															
Scientific Name	**Common Name**	**ROTAP**	**TSC Act**	**EPBC Act**	**DEC Web Muswellbrook Sheet (Feb 2006)**	**DEC Atlas Muswellbrook Sheet 20km (Feb 06)**	**DEC Atlas Unique (Jan 06)**	**DEH Protected Matters Search Tool 20km (Jan 06)**	**Recorded in Proposed Disturbance Area (Umwelt & HLA)**	**Recorded in Proposed Offset Area (Umwelt & HLA)**	**Abel Ecology (2005)**	**Literature Review**	**Birds Australia (Feb 2006)**	**Australian Museum (Feb 2006)**	**National Herbarium of NSW (Feb 2006)**	**Potential based on professional opinion**	**DEC Preliminary DGRs (June 2005)**
Olearia cordata		2VCi	V	V													✓
Ozothamnus tessellatus		2VC-	V	V	✓	✓	✓	✓				b			✓		
Persoonia marginata		2V	V	V		✓	✓										
Phebalium squamulosum subsp. verrucosum		2RC-													✓		
Philotheca ericifolia		3RC-	V	V	✓	✓	✓					b,c			✓		
Picris evae		3V	V	V								c					
Pomaderris bodalla		Rec. 2R	V		✓	✓	✓					c					✓
Pomaderris brunnea	rufous pomaderris	2VC-	V	V				✓									
Pomaderris costata		3RC-										c					
Pomaderris pauciflora		3RC-										b					
Pomaderris precaria		Rec. 2E										a,b					
Pomaderris queenslandica		**Rec .3V Ci**	**E**		✓	✓	✓		✓	✓		**a**			✓		
Pomaderris reperta		**Rec . 2E**	**E**		✓	✓	✓			✓	✓	**a,b**			✓		
Prostanthera cineolifera		2K	V	V	✓	✓	✓					b					
Prostanthera cryptandroides		2RC-t	V	V	✓	✓	✓	✓				a			✓		✓
Prostanthera discolor		2VC-	V	V								b					✓
Pterostylis gibbosa	Illawarra greenhood	2E	E	E													✓

Species Name		Record Source															
Scientific Name	**Common Name**	**ROTAP**	**TSC Act**	**EPBC Act**	**DEC Web Muswellbrook Sheet (Feb 2006)**	**DEC Atlas Muswellbrook Sheet 20km (Feb 06)**	**DEC Atlas Unique (Jan 06)**	**DEH Protected Matters Search Tool 20km (Jan 06)**	**Recorded in Proposed Disturbance Area (Umwelt & HLA)**	**Recorded in Proposed Offset Area (Umwelt & HLA)**	**Abel Ecology (2005)**	**Literature Review**	**Birds Australia (Feb 2006)**	**Australian Museum (Feb 2006)**	**National Herbarium of NSW (Feb 2006)**	**Potential based on professional opinion**	**DEC Preliminary DGRs (June 2005)**
Rulingia procumbens		3V	V	V	✓	✓	✓	✓				b			✓		
Senecio linearifolius var. *dangarensis*			E									c,e					
Thesium australe	austral toadflax	3VCi+	V	V				✓				c					
Wollemia nobilis	Wollemi pine	2ECit	E	E				✓									
White Box-Yellow Box-Blakely’s Red Gum Grassy Woodlands and Derived Native Grasslands				EEC				✓									
Weeping Myall Woodland EEC			**EEC**						✓	✓							
White box-yellow box-Blakely's red gum woodland			EEC														

APPENDIX B

Condition Assessment Proforma

Condition Assessment Proforma

Plot ID		**Date**		**Recorder**	
Eastings		**Northings**		**Aspect**	N NE E SE S SW W NW

Slope	0-5 6-10 11-20 21-30 30+	**Soil Depth**	Skeletal (<0.3 m) Shallow (0.3-1 m) Deep (>1 m)
Soil Texture	Sand sandy loam loam clay loam medium light clay heavy clay		
Fire	Severe moderate slight nil	**Cut Stps**	
Grazing	Severe moderate slight nil		
Erosion	Severe moderate slight nil	**Erosion Type**	N/A Sheet rill/gully pedestal scalding terracettes
Weeds	Severe moderate slight nil	**Dominant Species + percent cover**	N/A
Dumping	Severe moderate slight nil	**Feral Animals**	Severe moderate slight nil Species

Dieback	None mild moderate severe	**Mistletoe**	None mild moderate severe	**Insect attack**	None mild moderate severe

No. Logs >100 mm		**Types (%)**	N/A Solid + bark solid no bark hollow rotten decomposing
No. Stumps >100 mm at 0.5 m		**Types (%)**	N/A Solid + bark solid no bark hollow rotten decomposing
Rock (50-500 mm)	0 1-25 26-50 51-75 76-100	**Boulder/solid rock**	0 1-25 26-50 51-75 76-100
Horizontal perch sites	Bayonettes none few moderate many Bare branches none few moderate many other	**Loose tree bark No. of trees**	
Bark/litter at base of trees No. trees		**Vegetation as expected**	Yes No

Stratum	Average Max **Height (m)**	**% Cover**	**Dominant Growth Stage**	**Number of Species**	**2-3 Dominant Species**
Ground Layer		< 25 26-50 51-75 76-90 >90	Grass Forb Rush Sedge Cycad Bare Sub-shrub Lichen Other		
Understorey Layer		< 25 26-50 51-75 76-90 >90	Shrub % Sapling %		
Mid Understorey Layer		< 25 26-50 51-75 76-90 >90	Low tree % Shrub % Sapling %		
Canopy layer		< 25 26-50 51-75 76-90 >90	old growth % mature % middle-aged % regeneration % range of classes %		

DBH >100 mm 15 trees		1	2	3	4	5	6
7	8	9	10	11	12	13	14
15	16	17	18	19	20	21	22

KOALA FEED TREE SPECIES	**Count**	**Glossy black cockatoo tree species** (reprod. Age)	**Count**
Eucalyptus tereticornis (Forest Red Gum)		*Allocasuarina dimunuta*	
Eucalyptus microcorys (Tallowwood)		*Allocasuarina gymnanthera*	
Eucalyptus punctata (Grey Gum)		*Allocasuarina littoralis* (Black She Oak)	
Eucalyptus viminalis (Manna Gum)		*Allocasuarina luehmannii* (Bull Oak)	
Eucalyptus haemastoma (Broad-leaved Stringybark)		*Allocasuarina verticillata* (Drooping She-oak)	
Eucalyptus camaldulensis (River Red Gum)		*Casuarina glauca* (Swamp She-oak)	
Eucalyptus signata (Scribby Gum)		*Casuarina cunninghamiana* (River She Oak)	
Eucalyptus albens (White Box)		stags	
Eucalyptus populnea (Poplar Box)		Total Tree Count (all trees)	
Eucalyptus robusta (Swamp Mahogany)			

APPENDIX C

Hollow-bearing Trees and Koala Scat Proforma

Hollow-bearing Trees and Koala Scat Proforma

Record all hollow-bearing trees in quadrat including a scat search at each. Scat search a total of 15 trees >100 mm DBH including all hollow-bearing trees. If less than 15 then first 15 from corner.

Date: ____________________________ Recorder: __________________________________

Quadrat	Height (m)	% Dead Timber	DBH mm	Species	No. of koala scats	Macropod scats	BTP Scats	Rabbit Scats	Wombat Scats	Cow scats	Hollow Size					Hollow Orientation				Location of hollow				Hollow Height (m)
											Tiny <25 mm	Small 26-50	Med 51-100	Large 100-300	Massive 301+	Vertical	Horiz.	Angled up	Angled down	Trunk	Fork	Mid-Branch	Spout	

APPENDIX D

Water Body Proforma

Water Body Proforma

Date												
Recorder												
Dam Number												
GPS Waypoint Name												
Photo Numbers												
Area at 100% capacity	Width (m)											
	Length (m)											
% Open Water												
Edge length fringing reeds (m)	With reeds (m)											
	No reeds (m)											

APPENDIX E

Flora Species List

Flora Species List

The following list was developed from surveys of the Study Area as detailed in Section 3.3 of the main report. It includes all species of vascular plants observed within the Study Area during fieldwork. The list will not be comprehensive, because not all species are readily detected at any one time of the year. Many species flower only during restricted periods of the year, and some flower only once in several years. In the absence of flowering material, many of these species cannot be identified, or even detected.

Names of classes and families follow a modified Cronquist (1981) System.

Any species that could not be identified to the lowest taxonomic level are denoted in the following manner:

sp.	specimens that are identified to genus level only;
?	specimens for which identification was uncertain;
prob.	specimens for which identification was considered highly likely but not definite; and
poss.	specimens for which identification was considered likely but not definite.

The following abbreviations or symbols are used in the list:

asterisk (*)	denotes species not native to the study area;
subsp.	subspecies;
var.	variety;
f.	forma; and
X	hybrid.

Bold font denotes rare or threatened plant species.

All vascular plants recorded or collected were identified using keys and nomenclature in Harden (1992, 1993, 2000 & 2002) and Wheeler et al. (2002). Where known, changes to nomenclature and classification have been incorporated into the results, as derived from *PlantNET* (Botanic Gardens Trust 2006), the on-line plant name database maintained by the National Herbarium of New South Wales. Names revised since Harden (1992, 1993, 2000 & 2002) are listed in Table 3.1 of the main report.

Common names used follow Harden (1992, 1993, 2000 & 2002) where available, and draw on other sources such as local names where these references do not provide a common name.

Family/Subfamily	Scientific Name	Common Name
Filicopsida (Ferns)		
Adiantaceae	*Adiantum aethiopicum*	common maidenhair
	Cheilanthes austrotenuifolia	rock fern
	Cheilanthes distans	bristly cloak fern
	Cheilanthes sieberi subsp. *sieberi*	poison rock fern
	Pellaea falcata	sickle fern
	Pellaea nana	sickle fern
Aspleniaceae	*Asplenium flabellifolium*	necklace fern
Azollaceae	*Azolla* sp.	
Dennstaedtiaceae	*Histiopteris incisa*	bat's wing fern
	Pteridium esculentum	bracken
Marsileaceae	*Marsilea drummondii*	common nardoo
Cycadopsida (Cycads)		
Zamiaceae	*Macrozamia communis*	burrawang
	Macrozamia plurinervia	burrawang
	Macrozamia reducta	
	Macrozamia spiralis	burrawang
Coniferopsida (Conifers)		
Cupressaceae	*Callitris endlicheri*	black cypress pine
Magnoliopsida (Flowering Plants) – Liliidae (Monocots)		
Anthericaceae	*Arthropodium milleflorum*	vanilla lily
	Arthropodium species B	a vanilla lily
	Caesia sp.	a grass-lily
	Dichopogon fimbriatus	nodding chocolate lily
	Dichopogon strictus	chocolate lily
	Laxmannia compacta	
	Laxmannia gracilis	slender wire lily
	Thysanotus tuberosus	common fringe-lily
	Tricoryne elatior	yellow autumn-lily
Asparagaceae	**Asparagus asparagoides*	bridal creeper
Asphodelaceae	**Asphodelus fistulosus*	onion weed
	Bulbine semibarbata	native leek
Colchicaceae	*Wurmbea biglandulosa*	early Nancy
	Wurmbea dioica subsp. *dioica*	early Nancy
Commelinaceae	*Commelina cyanea*	scurvy weed
	Murdannia graminea	murdannia
Cyperaceae	*Carex appressa*	tall sedge
	Carex breviculmis	short-stem sedge
	Carex incomitata	a sedge
Cyperaceae (cont)	*Carex inversa*	knob sedge
	Cyperus difformis	
	Cyperus enervis	a sedge
	Cyperus fulvus	sticky sedge

Family/Subfamily	Scientific Name	Common Name
	Cyperus gracilis	a sedge
	Cyperus laevis	a sedge
	Cyperus sanguinolentus	
	Eleocharis cylindrostachys	a spike-rush
	Eleocharis plana	flat spike-sedge
	Fimbristylis dichotoma	common fringe-rush
	Gahnia aspera	rough saw-sedge
	Lepidosperma laterale	variable saw-sedge
	Schoenus apogon	common bog-rush
	Scleria mackaviensis	razor grass
Hydrocharitaceae	*Ottelia ovalifolia*	swamp lily
Hypoxidaceae	*Hypoxis pratensis*	golden weather-grass
Iridaceae	**Romulea rosea* var. *australis*	onion grass
Juncaceae	**Juncus acutus* subsp. *acutus*	sharp rush
	Juncus filicaulis	
	Juncus homalocaulis	a rush
	Juncus subsecundus	
	Juncus subsecundus—remotiflorus	
	Juncus usitatus	a rush
	Luzula flaccida	a woodrush
Juncaginaceae	*Triglochin procerum*	water ribbons
	Triglochin striatum	streaked arrow grass
Lomandraceae	*Lomandra confertifolia* subsp. *pallida*	a mat-rush
	Lomandra filiformis subsp. *coriacea*	wattle mat-rush
	Lomandra filiformis subsp. *filiformis*	wattle mat-rush
	Lomandra glauca	pale mat-rush
	Lomandra longifolia	spiny-headed mat-rush
	Lomandra multiflora subsp. *multiflora*	many-flowered mat-rush
Luzuriagaceae	*Eustrephus latifolius*	wombat berry
	Geitonoplesium cymosum	scrambling lily
Orchidaceae	*Acianthus* sp.	
	Caladenia caerulea	blue caladenia
	Caladenia carnea var. *carnea*	pink fairy
Orchidaceae (cont)	***Cymbidium canaliculatum***	**tiger orchid**
	Diuris tricolor	**painted diuris**
	Eriochilus cucullatus	parson's bands
	Glossodia major	waxlip orchid
	Microtis parviflora	slender onion orchid
	Pterostylis bicolor	
	Pterostylis cycnocephala	swan greenhood
	Pterostylis reflexa	

Family/Subfamily	Scientific Name	Common Name
	Thysanotus sp.	a sun orchid
Phormiaceae	*Dianella caerulea* var. *caerulea*	blue flax lily
	Dianella longifolia	blue flax lily
	Dianella revoluta	blue falx lily
	Stypandra glauca	nodding blue lily
Poaceae	*Agrostis* sp.	bent grass
	**Aira cupaniana*	silvery hairgrass
	Ancistrachne uncinulata	hooky grass
	Aristida acuta	a three-awn grass
	Aristida benthamii var. *benthamii*	three-awned spear grass
	Aristida blakei	
	Aristida calycina var. *calycina*	dark wiregrass
	Aristida calycina var. *praealta*	dark wiregrass
	Aristida jerichoensis var. *jerichoensis*	Jericho wiregrass
	Aristida leichhardtiana	
	Aristida queenslandica var. *queenslandica*	a threeawn grass
	Aristida ramosa	wire grass
	Aristida ramosa var. *scaberula*	wire grass
	Aristida ramosa var. *speciosa*	wire grass
	Aristida vagans	threeawn speargrass
	Austrodanthonia bipartita	wallaby grass
	Austrodanthonia caespitosa	ringed wallaby grass
	Austrodanthonia fulva	wallaby grass
	Austrodanthonia monticola	a wallaby grass
	Austrodanthonia racemosa var. *obtusata*	white top
	Austrodanthonia racemosa var. *racemosa*	white top
	Austrodanthonia richardsonii	straw wallaby-grass
	Austrodanthonia tenuior	a wallaby grass
Poaceae (cont)	*Austrostipa ?aristiglumis*	plains grass
	Austrostipa ramosissima	stout bamboo grass
	Austrostipa scabra subsp. *falcata*	speargass
	Austrostipa scabra subsp. *scabra*	corkscrew grass
	Austrostipa setacea	corkscrew grass
	Austrostipa verticillata	slender bamboo grass
	**Avena fatua*	wild oats
	**Avena sativa*	oats
	Bothriochloa biloba	**lobed bluegrass**
	Bothriochloa decipiens	red grass

Family/Subfamily	Scientific Name	Common Name
	Bothriochloa macra	red grass
	**Briza minor*	shivery grass
	**Bromus molliformis*	a soft brome
	Cenchrus caliculatus	hillside burrgrass
	Chloris divaricata var. *divaricata*	slender chloris
	**Chloris gayana*	Rhodes grass
	Chloris truncata	windmill grass
	Chloris ventricosa	tall chloris
	Cleistochloa rigida	
	Cymbopogon refractus	barbed wire grass
	Cynodon dactylon	couch
	Dichanthium sericeum subsp. *sericeum*	Queensland bluegrass
	Dichelachne crinita	longhair plumegrass
	Dichelachne micrantha	shorthair plumegrass
	Digitaria breviglumis	
	Digitaria brownii	cotton panic grass
	Digitaria diffusa	
	Digitaria divaricatissima	umbrella grass
	Digitaria parviflora	small-flowered finger grass
	Digitaria ramularis	a finger grass
	Echinopogon caespitosus	tufted hedgehog grass
	Echinopogon ovatus	forest hedgehog grass
	**Ehrharta erecta*	panic veldtgrass
	**Eleusine tristachya*	goose grass
	Elymus scaber var. *scaber*	common wheatgrass
	Enneapogon gracilis	slender nineawn
	Enteropogon acicularis	a windmill grass
	Entolasia marginata	bordered panic
	Entolasia stricta	wiry panic
Poaceae (cont)	*Eragrostis alveiformis*	
	Eragrostis benthamii	
	Eragrostis brownii	Brown's lovegrass
	Eragrostis falcata	sickle lovegrass
	Eragrostis lacunaria	purple lovegrass
	Eragrostis leptostachya	paddock lovegrass
	Eragrostis parviflora	weeping lovegrass
	Eriochloa pseudoacrotricha	early spring grass
	Eulalia aurea	silky browntop
	**Hordeum leporinum*	barley grass
	Imperata cylindrica var. *major*	blady grass
	Joycea pallida	silvertop wallaby grass
	Lachnagrostis filiformis	blown grass
	**Lolium loliaceum*	stiff ryegrass

Family/Subfamily	Scientific Name	Common Name
	**Lolium rigidum*	Wimmera ryegrass
	Microlaena stipoides var. *stipoides*	weeping grass
	Oplismenus aemulus	
	Oplismenus imbecillis	
	Panicum effusum	hairy panic
	Panicum simile	hairy panic
	Paspalidium albovillosum	pale summer grass
	Paspalidium aversum	bent summer-grass
	Paspalidium caespitosum	brigalow grass
	Paspalidium constrictum	knottybutt grass
	Paspalidium distans	
	Paspalidium gracile	slender panic
	**Paspalum dilatatum*	paspalum
	Paspalum distichum	saltwater couch
	**Pennisetum clandestinum*	kikuyu grass
	**Phalaris aquatica*	phalaris
	Phragmites australis	common reed
	Poa labillardieri var. *labillardieri*	tussock
	**Setaria gracilis*	slender pigeon grass
	Sporobolus creber	slender rat's tail grass
	Sporobolus elongatus	slender rat's tail grass
	Themeda australis	kangaroo grass
Potamogetonaceae	*Potamogeton ochreatus*	blunt pondweed
Typhaceae	*Typha orientalis*	broad-leaved cumbungi
Xanthorrhoeaceae	*Xanthorrhoea johnsonii*	a grass tree
Magnoliopsida (Flowering Plants) – Magnoliidae (Dicots)		
Acanthaceae	*Brunoniella australis*	blue trumpet
	Brunoniella pumilio	dwarf brunoniella
	Rostellularia adscendens subsp. *adscendens*	red drums
	Rostellularia adscendens var. *pogonanthera*	
Aizoaceae	**Galenia pubescens*	galenia
Amaranthaceae	*Alternanthera nana*	hairy joyweed
	Alternanthera species A	a joyweed
	**Gomphrena celosioides*	gomphrena weed
Anacardiaceae	**Schinus areira*	pepper tree
Apiaceae	*Centella* sp.	a pennywort
	**Cyclospermum leptophyllum*	slender celery
	Daucus glochidiatus	native carrot
	Daucus glochidiatus form A	native carrot
	Daucus glochidiatus form F	native carrot
	**Foeniculum vulgare*	fennel
	Hydrocotyle laxiflora	stinking pennywort

Family/Subfamily	Scientific Name	Common Name
	Platysace ericoides	heath platysace
Apocynaceae	*Marsdenia suaveolens*	scented marsdenia
	Marsdenia viridiflora	native pear
	Parsonsia eucalyptophylla	gargaloo
Asclepiadaceae	**Gomphocarpus fruticosus*	narrow-leaved cotton-bush
Asteraceae	**Arctotheca calendula*	capeweed
	**Bidens pilosa*	cobbler's pegs
	Brachyscome angustifolia	
	Brachyscome ciliaris var. *subintegrifolia*	variable daisy
	Brachyscome curvicarpa	
	Brachyscome multifida var. *multifida*	cut-leaved daisy
	Bracteantha bracteata	golden everlasting
	Calocephalus citreus	lemon beauty-heads
	Calotis cuneifolia	purple burr-daisy
	Calotis lappulacea	yellow burr-daisy
	**Carduus nutans* subsp. *nutans*	nodding thistle
	**Carthamus lanatus*	saffron thistle
	Cassinia aculeata	dolly bush
	Cassinia arcuata	sifton bush
	Cassinia cunninghamii	a cassinia
Asteraceae (cont)	*Cassinia quinquefaria*	cough-bush
	Cassinia species D	a cassinia
	Cassinia prob. *uncata*	sticky cassinia
	**Centaurea melitensis*	Maltese cockspur
	Centipeda minima var. *minima*	spreading sneezeweed
	**Chondrilla juncea*	skeleton weed
	Chrysocephalum apiculatum	common everlasting
	Chrysocephalum semipapposum	clustered everlasting
	**Cirsium vulgare*	spear thistle
	**Conyza bonariensis*	flaxleaf fleabane
	**Conyza sumatrensis*	tall fleabane
	Cotula australis	common cotula
	**Cotula coronopifolia*	water buttons
	Cymbonotus lawsonianus	bears-ear
	**Dittrichia graveolens*	stinkwort
	Eclipta platyglossa	yellow twin-heads
	Euchiton involucratus	star cudweed
	**Facelis retusa*	
	**Gamochaeta spicata*	spiked cudweed
	Glossogyne tannensis	cobbler's tack
	Hedypnois rhagadioloides	Cretan weed

Family/Subfamily	Scientific Name	Common Name
	subsp. *cretica*	
	Helichrysum scorpioides	button everlasting
	**Hypochaeris radicata*	catsear
	Lagenifera gracilis (prob.)	slender lagenophora
	Lagenifera stipitata	blue bottle-daisy
	Olearia elliptica subsp. *elliptica*	sticky daisy bush
	Ozothamnus diosmifolius	white dogwood
	Podolepis neglecta	
	Pseuderanthemum variabile	pastel flower
	Pseudognaphalium luteoalbum	Jersey cudweed
	**Schkuhria pinnata*	
	Senecio hispidulus var. *dissectus*	hill fireweed
	Senecio lautus subsp. *dissectifolius*	variable groundsel
	**Senecio madagascariensis*	fireweed
	Senecio quadridentatus	cotton fireweed
	Sigesbeckia australiensis	
	Sigesbeckia orientalis subsp. *orientalis*	Indian weed
	Solenogyne bellioides	a solenogyne
Asteraceae (cont)	**Sonchus oleraceus*	common sowthistle
	**Tagetes minuta*	stinking Roger
	**Taraxacum officinale*	dandelion
	**Tolpis umbellata*	
	Vernonia cinerea var. *cinerea*	
	Vittadinia cervicularis var. *subcervicularis*	fuzzweed
	Vittadinia cuneata var. *cuneata*	fuzzweed
	Vittadinia cuneata var. *cuneata* f. *minor*	fuzzweed
	Vittadinia dissecta var. *hirta*	fuzzweed
	Vittadinia muelleri	fuzzweed
	Vittadinia pterochaeta	winged New Holland daisy
	Vittadinia pustulata	fuzzweed
	Vittadinia sulcata	fuzzweed
	**Xanthium occidentale*	Noogoora burr
	**Xanthium spinosum*	Bathurst burr
Bignoniaceae	*Pandorea pandorana* subsp. *pandorana*	wonga wonga vine
Boraginaceae	*Cynoglossum australe*	Australian hound's tongue
	Cynoglossum suaveolens	sweet hound's-tongue
	Halgania brachyrhyncha	halgania
Brassicaceae	**Brassica* sp.	

Family/Subfamily	Scientific Name	Common Name
	**Capsella bursa-pastoris*	shepherd's purse
	**Lepidium africanum*	common peppercress
	Lepidium pseudohyssopifolium	a peppercress
	**Rapistrum rugosum*	turnip weed
	**Sisymbrium irio*	London rocket
Cactaceae	*Harrisia tortuosa*	harrisia cactus
	**Opuntia aurantiaca*	tiger pear
	**Opuntia stricta* var. *stricta*	common prickly pear
Campanulaceae	*Wahlenbergia communis*	tufted bluebell
	Wahlenbergia fluminalis	river bluebell
	Wahlenbergia gracilenta	annual bluebell
	Wahlenbergia gracilis	sprawling bluebell
	Wahlenbergia littoricola	
	Wahlenbergia luteola	native bluebell
	Wahlenbergia planiflora	native bluebell
	Wahlenbergia stricta	tall bluebell
	Wahlenbergia victoriensis	
Caryophyllaceae	**Arenaria leptoclados*	lesser thyme-leaved sandwort
	**Cerastium glomeratum*	mouse-ear chickweed
	Gypsophila tubulosa	annual chalkwort
	**Paronychia brasiliana*	Chilean whitlow wort
	**Petrorhagia nanteuilii*	proliferous pink
	**Petrorhagia velutina*	velvet pink
	**Silene gallica* var. *gallica*	a campion
	**Spergularia rubra*	sandspurry
	Spergularia sp. 3	
	Stellaria flaccida	forest starwort
	**Stellaria media*	common chickweed
	Stellaria pungens	prickly starwort
Casuarinaceae	*Allocasuarina diminuta* subsp. *diminuta*	
	Allocasuarina distyla	
	Allocasuarina gymnanthera	
	Allocasuarina littoralis	black sheoak
	Allocasuarina luehmannii	bulloak
	Allocasuarina verticillata	drooping sheoak
	Casuarina glauca	swamp oak
Celastraceae	*Maytenus cunninghamii*	yellow-berry bush
	Maytenus silvestris	narrow-leaved orangebark
Chenopodiaceae	*Atriplex semibaccata*	creeping saltbush
	**Chenopodium album*	fat hen
	Chenopodium melanocarpum	black crumbweed
	Chenopodium pumilio	small crumbweed
	Dysphania glomulifera subsp.	

Family/Subfamily	Scientific Name	Common Name
	glomulifera	
	Einadia hastata	berry saltbush
	Einadia nutans subsp. *nutans*	climbing saltbush
	Einadia polygonoides	knotweed goosefoot
	Einadia trigonos subsp. *leiocarpa*	fishweed
	Einadia trigonos subsp. *stellulata*	
	Enchylaena tomentosa	ruby saltbush
	Maireana decalvans	black cotton bush
	Maireana enchylaenoides	
	Maireana microphylla	eastern cottonbush
	Sclerolaena birchii	galvanized burr
	Sclerolaena muricata	black rolypoly
Chloanthaceae	*Spartothamnella juncea*	square-stemmed broom
Clusiaceae	*Hypericum gramineum*	small St. John's wort
Convolvulaceae	*Convolvulus erubescens*	bindweed
	Dichondra repens	kidney weed
	Dichondra species A	kidney weed
	Evolvulus alsinoides var. *decumbens*	
Crassulaceae	*Crassula sieberiana*	Australian stonecrop
Cucurbitaceae	**Citrullus lanatus* var. *lanatus*	wild melon
Dilleniaceae	*Hibbertia acicularis*	prickly Guinea flower
	Hibbertia aspera	rough Guinea flower
	Hibbertia linearis	Guinea flower
	Hibbertia sp. nov.	
	Hibbertia obtusifolia	Guinea flower
	Hibbertia riparia	erect Guinea flower
Droseraceae	*Drosera peltata*	sundew
Epacridaceae	*Epacris microphylla* var. *microphylla*	
	Leucopogon muticus	blunt beard-heath
	Melichrus erubescens	ruby urn heath
	Melichrus urceolatus	urn heath
	Styphelia triflora	five corners
Euphorbiaceae	*Beyeria viscosa*	sticky wallaby-bush
	Breynia oblongifolia	coffee bush
	Chamaesyce dallachyana	spurge
	Chamaesyce drummondii	caustic weed
	Euphorbia eremophila	desert spurge
	**Euphorbia peplus* (prob.)	petty spurge
	Euphorbia planiticola	plains spurge
	Phyllanthus gasstroemii	
	Phyllanthus hirtellus	thyme spurge
	Phyllanthus similis	

Family/Subfamily	Scientific Name	Common Name
	Phyllanthus virgatus	spurge
	Poranthera microphylla	small poranthera
	**Ricinus communis*	castor oil plant
Fabaceae (Faboideae)	*Bossiaea buxifolia*	
	Bossiaea obcordata	spiny bossiaea
	Bossiaea prostrata—buxifolia	
	Chorizema parviflorum	eastern flame pea
	Daviesia acicularis	a bitter pea
	Daviesia genistifolia	broom bitter pea
Fabaceae (Faboideae) (cont)	*Daviesia ulicifolia* subsp. *ulicifolia*	gorse bitter pea
	Desmodium brachypodum	large tick-trefoil
	Desmodium gunnii	slender tick trefoil
	Desmodium rhytidophyllum	rusty tick-trefoil
	Desmodium varians	slender tick-trefoil
	Dillwynia sericea	
	Glycine ?stenophita	
	Glycine clandestina	twining glycine
	Glycine latifolia	glycine
	Glycine tabacina	variable glycine
	Hardenbergia violacea	false sarsaparilla
	Hovea linearis	narrow-leaf hovea
	Indigofera australis	native indigo
	Jacksonia scoparia	dogwood
	**Medicago sativa*	lucerne
	Lotus australis	Australian trefoil
	Pultenaea microphylla	spreading bush-pea
	Swainsona oroboides	
	Templetonia stenophylla	leafy templetonia
	**Trifolium arvense*	haresfoot clover
	**Trifolium dubium*	yellow suckling clover
	**Trifolium fragiferum*	strawberry clover
	**Trifolium globosum*	globe clover
	**Trifolium glomeratum*	clustered clover
	**Trifolium repens*	white clover
	Zornia dyctiocarpa var. *dyctiocarpa*	zornia
Fabaceae (Mimosoideae)	*Acacia binervia*	coast myall
	Acacia cheelii	motherumbah
	Acacia crassa subsp. *crassa*	curracabah
	Acacia deanei subsp. *deanei*	Deane's wattle
	Acacia decora	western golden wattle
	Acacia doratoxylon	currawang
	Acacia falcata	hickory wattle
	Acacia falciformis	broad-leaved hickory

Family/Subfamily	Scientific Name	Common Name
	Acacia hakeoides	hakea wattle
	Acacia implexa	hickory wattle
	Acacia irrorata	greeen wattle
	Acacia linearifolia	stringybark wattle
	Acacia melvillei	yarran
Fabaceae (Mimosoideae) (cont)	*Acacia paradoxa*	kangaroo thorn
	Acacia parvipinnula	silver-stemmed wattle
	Acacia pendula	**weeping myall**
	Acacia piligera	gold-dust wattle
	Acacia pravifolia	coil-pod wattle
	Acacia salicina	cooba
	Acacia spectabilis	Mudgee wattle
	Acacia uncinata	gold-dust wattle
Fumariaceae	**Fumaria muralis* subsp. *muralis*	wall fumitory
Geraniaceae	**Erodium cicutarium*	common storksbill
	Erodium crinitum	blue storksbill
	Geranium solanderi var. *solanderi*	native geranium
Goodeniaceae	*Brunonia australis*	blue pincushion
	Dampiera lanceolata var. *lanceolata*	a dampiera
	Goodenia hederacea subsp. *hederacea*	ivy goodenia
	Goodenia heterophylla	a goodenia
	Goodenia macbarronii	**narrow goodenia**
	Goodenia ovata	hop goodenia
	Goodenia pinnatifida	
	Goodenia rotundifolia	a goodenia
Haloragaceae	*Gonocarpus elatus*	hill raspwort
	Haloragis heterophylla	variable raspwort
	Myriophyllum verrucosum	red water-milfoil
Lamiaceae	*Ajuga australis*	Austral bugle
	**Marrubium vulgare*	horehound
	Prostanthera nivea	snowy mint-bush
	Prostanthera nivea var. *nivea*	snowy mint-bush
	Prostanthera ovalifolia	oval-leaf mint-bush
	Prostanthera prunelloides	prunella mint-bush
	Scutellaria humilis	dwarf skullcap
Lobeliaceae	*Isotoma axillaris*	showy isotome
	Pratia purpurascens	whiteroot
Loganiaceae	*Mitrasacme polymorpha*	
Loranthaceae	*Amyema cambagei*	sheoak mistletoe
	Amyema congener subsp. *congener*	a mistletoe
	Amyema gaudichaudii	paperbark mistletoe

Family/Subfamily	Scientific Name	Common Name
	Amyema miquelii	box mistletoe
Loranthaceae (cont)	*Amyema pendulum* subsp. *pendulum*	drooping mistletoe
	Lysiana exocarpi subsp. *tenuis*	harlequin mistletoe
	Muellerina eucalyptoides	a mistletoe
Malvaceae	*Abutilon oxycarpum*	flannel weed
	Gossypium sturtianum var. *sturtianum*	Sturt's desert rose
	Hibiscus sturtii var. *sturtii*	hill hibiscus
	**Malva parviflora*	small-flowered mallow
	**Modiola caroliniana*	red-flowered mallow
	**Pavonia hastata*	pavonia
	Sida corrugata	corrugated sida
	Sida filiformis	
	Sida petrophila	
	**Sida rhombifolia*	Paddy's lucerne
	Sida spinosa	
	Sida subspicata	spiked sida
	Sida trichopoda	
Meliaceae	*Melia azedarach*	white cedar
Moraceae	*Ficus rubiginosa* form *rubiginosa*	rusty fig
Myoporaceae	*Eremophila debilis*	winter apple
	Eremophila deserti	turkeybush
	Myoporum montanum	western boobialla
Myrsinaceae	*Rapanea variabilis*	muttonwood
Myrtaceae	*Angophora floribunda*	rough-barked apple
	Backhousia myrtifolia	grey myrtle
	Callistemon linearis	narrow-leaved bottlebrush
	Eucalyptus ?bridgesiana	apple box
	Eucalyptus albens—moluccana	white/grey box
	Eucalyptus blakelyi	Blakely's red gum
	Eucalyptus blakelyi—tereticornis	
	Eucalyptus crebra	narrow-leaved ironbark
	Eucalyptus dawsonii	slaty box
	Eucalyptus dwyeri	Dwyer's red gum
	Eucalyptus fibrosa	broad-leaved ironbark
	Eucalyptus melliodora	yellow box
	Eucalyptus microcarpa	western grey box
	Eucalyptus moluccana	grey box
	Eucalyptus moluccana—microcarpa	
Myrtaceae (cont)	*Eucalyptus punctata*	grey gum

Family/Subfamily	Scientific Name	Common Name
	Eucalyptus tereticornis	forest red gum
	Kunzea ambigua	tick bush
	Kunzea sp. 'Mt Kaputar'	a kunzea
	Kunzea species D	
	Leptospermum parvifolium	small-leaf tea tree
	Leptospermum polyanthum	a tea tree
	Leptospermum trinervium	flaky-barked tea tree
	Melaleuca decora	white feather honeymyrtle
	Melaleuca nodosa	ball honeymyrtle
	Melaleuca sieberi	Sieber's paperbark
	Melaleuca uncinata	broombush
	Micromyrtus ciliata	fringed heath-myrtle
	Micromyrtus sessilis	a heath-myrtle
Nyctaginaceae	*Boerhavia dominii*	tarvine
Oleaceae	*Notelaea microcarpa* var. *microcarpa*	native olive
Onagraceae	*Ludwigia peploides*	water primrose
Oxalidaceae	*Oxalis ?chnoodes*	a wood sorrel
	Oxalis exilis	a wood sorrel
	Oxalis perennans	grassland wood sorrel
Phytolaccaceae	**Phytolacca octandra*	inkweed
Pittosporaceae	*Bursaria spinosa* subsp. *spinosa*	blackthorn
	Pittosporum multifloruum	orange thorn
Plantaginaceae	*Plantago debilis*	slender plantain
	**Plantago lanceolata*	lambs' tongues
	Plantago varia	variable plantain
Polygonaceae	*Persicaria prostrata*	creeping knotweed
	**Polygonum arenastrum*	wireweed
	Rumex brownii	swamp dock
	**Rumex crispus*	curled dock
Portulacaceae	*Calandrinia eremaea*	small purslane
	Calandrinia pickeringii	
Primulaceae	**Anagallis arvensis*	scarlet pimpernell
Proteaceae	***Grevillea montana***	**a grevillea**
	Isopogon dawsonii	drumsticks
	Persoonia linearis	narrow-leaved geebung
Ranunculaceae	*Clematis aristata*	old man's beard
	Clematis glycinoides var. *glycinoides*	headache vine
	Ranunculus sp	a buttercup
Rhamnaceae	*Alphitonia excelsa*	red ash
	Pomaderris ?intermedia	a pomaderris
	Pomaderris ferruginea	rusty pomaderris
	Pomaderris queenslandica	

Family/Subfamily	Scientific Name	Common Name
	Pomaderris reperta	
	Spyridium buxifolium	
Rosaceae	*Rubus fruitcosus* sp. *agg.*	blackberry
Rubiaceae	*Asperula conferta*	common woodruff
	Galium binifolium	a bedstraw
	Galium gaudichaudii	rough bedstraw
	Galium migrans	a bedstraw
	**Galium murale*	small bedstraw
	Galium propinquum	Maori bedstraw
	Opercularia diphylla	stinkweed
	Opercularia varia	variable stinkweed
	Pomax umbellata	pomax
	Psydrax odorata (syn. *Canthium buxifolium* and *C. odoratum*)	iamboto
	**Richardia stellaris*	field madder
Rutaceae	*Boronia anethifolia*	narrow-leaved boronia
	Correa reflexa var. *reflexa*	common correa
	Geijera parviflora	wilga
	Geijera salicifolia var. *salicifolia*	brush wilga
	Phebalium squamulosum subsp. *gracile*	scaly phebalium
	Phebalium squamulosum subsp. *lineare*	scaly phebalium
	Philotheca myoporoides subsp. *myoporoides*	a waxflower
	Zieria cytisoides	downy zieria
Salicaceae	**Salix bablyonica*	weeping willow
	**Salix matsudana*	tortured willow
Santalaceae	*Exocarpos cupressiformis*	native cherry
	Santalum lanceolatum	northern sandalwood
Sapindaceae	*Dodonaea triangularis*	a hop bush
	Dodonaea viscosa subsp. *cuneata*	wedge-leaf hop bush
	Dodonaea viscosa subsp. *mucronata*	a hop bush
	Dodonaea viscosa subsp. *spatulata*	a hop bush
Scrophulariaceae	*Gratiola pedunculata*	
	**Verbascum virgatum*	twiggy mullein
	Veronica calycina	hairy speedwell
	Veronica plebeia	trailing speedwell
Solanaceae	**Datura ferox*	fierce thornapple
	**Lycium ferocissimum*	African boxthorn
	Nicotiana suaveolens	native tobacco

Family/Subfamily	Scientific Name	Common Name
	Solanum brownii	violet nightshade
	Solanum campanulatum	a nightshade
	Solanum cinereum	Narrawa burr
	**Solanum nigrum*	black-berry nightshade
	Solanum opacum	green-berry nightshade
	Solanum prinophyllum	forest nightshade
	Solanum stelligerum	devil's needles
Stackhousiaceae	*Stackhousia monogyna*	creamy candles
	Stackhousia muricata	western stackhousia
	Stackhousia viminea	slender stackhousia
Sterculiaceae	*Brachychiton populneus* subsp. *populneus*	kurrajong
	Commersonia rosea	
	Lasiopetalum longistamineum	
	Rulingia dasyphylla	kerrawang
Thymelaeaceae	*Pimelea latifolia* subsp. *elliptifolia*	a rice flower
	Pimelea latifolia subsp. *latifolia*	a rice flower
Urticaceae	**Urtica urens*	small nettle
Verbenaceae	*Clerodendrum tomentosum*	hairy clerodendrum
	**Verbena bonariensis*	purpletop
	**Verbena litoralis*	coastal verbena
	**Verbena rigida* var. *rigida*	veined verbena
Violaceae	*Viola hederacea*	ivy-leaved violet

APPENDIX F

Test for Ecological Significance
(NSW TSC Act 1995)

Test for Ecological Significance
(NSW *Threatened Species Conservation Act* 1995)

Threatened Species

1. Green and golden bell frog – *Litoria aurea*

The green and golden bell frog (*Litoria aurea*) is mainly recorded from small, coastal, or near coastal populations (DEC 2006cd). The locations of known populations occur over the species' former range, however they are widely separated and many are isolated. Large populations in NSW are located around the metropolitan areas of Sydney, Shoalhaven and mid north coast (one an island population) (DEC 2006cd). There is only one known population on the NSW Southern Tablelands. This species inhabits marshes, dams and stream-sides, particularly those containing bullrushes (*Typha* spp.) or spikerushes (*Eleocharis* spp.). Optimum habitat includes water-bodies that are unshaded, free of predatory fish such as plague minnow (*Gambusia holbrooki*), have a grassy area nearby and diurnal sheltering sites available (DEC 2006cd). Some sites, particularly in the Greater Sydney region, occur in highly disturbed areas. The species is active by day and usually breeds in summer when conditions are warm and wet. Tadpoles feed on algae and other plant-matter; adults eat mainly insects, but also other frogs (DEC 2006cd).

a) Whether the life cycle of the species is likely to be disrupted such that a local viable population of the species is likely to be placed at risk of extinction.

The green and golden bell frog (*Litoria aurea*) was not identified within the Study Area, despite extensive, seasonal surveys. It is considered that a local viable population of this species is not likely to be present within the Study Area.

The Anvil Hill Project is unlikely to disrupt a local viable population of the species, such that the species is likely to be placed at risk of extinction.

b) In relation to the regional distribution of the habitat of the threatened species, whether a significant area of known habitat is to be modified or removed, or isolated from currently interconnecting or proximate areas.

The green and golden bell frog (*Litoria aurea*) was not identified within the Study Area, despite extensive, seasonal surveys. The Study Area does not contain a significant area of known habitat for this species, and it is considered unlikely that this species is present within the Study Area.

The majority of records of this species from the Hunter Valley come from coastal areas, around Newcastle. There are a small number of records as far west as the Lake Liddell area, however these are the western-most records of this species in the Hunter Valley.

A significant area of known habitat for this species will not be modified or removed, or isolated from currently interconnecting or proximate areas as a result of the Anvil Hill Project.

c) Whether the species, or its habitat, are adequately represented in conservation reserves (or other similar protected areas) in the region.

There have been no sightings of the green and golden bell frog (*Litoria aurea*) recorded within any of the nine conservation reserves identified within the region surrounding the Study Area. As such, it is not considered that this species is adequately represented in conservation reserves within the region.

d) Whether the species is at the limit of its known distribution.

The green and golden bell frog (*Litoria aurea*) is mainly recorded from small, coastal, or near coastal populations (DEC 2006cd). The locations of known populations occur over the species' former range, however they are widely separated and many are isolated. Large populations in NSW are located around the metropolitan areas of Sydney, Shoalhaven and mid north coast (one being an island population) (DEC 2006cd). The Study Area is not at the western limit of the known distribution for this species in NSW, however a record of this species in the Study Area would represent the western-most record of this species in the Hunter Valley.

2. Pink-tailed legless-lizard – *Aprasia parapulchella*

The pink-tailed legless-lizard (*Aprasia parapulchella*) is a flap-footed lizard, where the limbs are reduced to small scaly flaps, such that the lizard appears limbless (Wilson & Swan 2003). The pink-tailed legless-lizard has a scattered distribution which includes the central tablelands, southern tablelands, central western slopes and south western slopes of NSW (Swan et al. 2004). There is a concentration of populations in the Canberra/Queanbeyan Region. Other populations have been recorded near Cooma, Yass, Bathurst, Albury and West Wyalong. This species is also found in the Australian Capital Territory (DEC 2006). This species is known to inhabit sloping, open woodland areas with predominantly native grassy ground layers, particularly those dominated by kangaroo grass (*Themeda australis*). Sites are typically well-drained, with rocky outcrops or scattered, partially-buried rocks. It is commonly found beneath small, partially-embedded rocks and appear to spend considerable time in burrows below these rocks; the burrows have been constructed by and are often still inhabited by small black ants and termites (DEC 2006au). Suitable rock cover seems to include partially buried rocks with ant tunnels (Wilson & Swan 2003 and Swan et al. 2004).

a) Whether the life cycle of the species is likely to be disrupted such that a local viable population of the species is likely to be placed at risk of extinction.

The pink-tailed legless-lizard (*Aprasia parapulchella*) was not identified within the Study Area, despite extensive, seasonal surveys. It is considered that a local viable population of this species is not likely to be present within the Study Area.

The Anvil Hill Project is unlikely to disrupt a local viable population of the species, such that the species is likely to be placed at risk of extinction.

b) In relation to the regional distribution of the habitat of the threatened species, whether a significant area of known habitat is to be modified or removed, or isolated from currently interconnecting or proximate areas.

The pink-tailed legless-lizard (*Aprasia parapulchella*) was not identified within the Study Area, despite extensive, seasonal surveys. The Study Area does not contain a significant area of known habitat for this species, and it is considered unlikely that this species is present within the Study Area.

There are very few records of this species within New South Wales. The nearest record to the Study Area is at the western edge of Goulburn River National Park, this being the only record of this species in the Hunter region.

A significant area of known habitat for this species will not be modified or removed, or isolated from currently interconnecting or proximate areas as a result of the Anvil Hill Project.

c) Whether the species, or its habitat, are adequately represented in conservation reserves (or other similar protected areas) in the region.

There is one record of the pink-tailed legless lizard (*Aprasia parapulchella*) documented for Goulburn River National Park (DEC 2006au). It is likely that this species is adequately protected.

d) Whether the species is at the limit of its known distribution.

The pink-tailed legless-lizard (*Aprasia parapulchella*) has a scattered distribution which includes the central tablelands, southern tablelands, central western slopes and south western slopes of NSW (Swan et al. 2004). There is a concentration of populations in the Canberra/Queanbeyan Region. Other populations have been recorded near Cooma, Yass, Bathurst, Albury and West Wyalong. This species is also found in the Australian Capital Territory (DEC 2006au). A record of this species from the Study Area would represent the northern-most record of this species, as well as a rare record of this species from the Hunter region.

3. Rosenberg's goanna – *Varanus rosenbergi*

Rosenberg's goanna (*Varanus rosenbergi*) is a large goanna, growing up to 1.5 metres in length (DEC 2006av). This species is known to occur on the Sydney Sandstone in Wollemi National Park to the north-west of Sydney, in the Goulburn and ACT regions and near Cooma in the south. There are records from the south west slopes near Khancoban and Tooma River. It also occurs in South Australia and Western Australia (DEC 2006av). Isolated populations occur in Victoria and coastal NSW (Cogger 1994). This species is commonly found in coastal heath, humid woodland and wet and dry sclerophyll forest (Cogger 1994). Rosenberg's goannas are associated with termites, particularly termite mounds, which are a critical habitat component for this goanna. Individuals require large areas of habitat and will shelter in burrows, hollow logs, rock crevices and burrows (DEC 2006av).

a) Whether the life cycle of the species is likely to be disrupted such that a local viable population of the species is likely to be placed at risk of extinction.

Rosenberg's goanna (*Varanus rosenbergi*) was not identified within the Study Area, despite extensive, seasonal surveys. It is considered that a local viable population of this species is not likely to be present within the Study Area.

The Anvil Hill Project is unlikely to disrupt a local viable population of the species, such that the species is likely to be placed at risk of extinction.

b) In relation to the regional distribution of the habitat of the threatened species, whether a significant area of known habitat is to be modified or removed, or isolated from currently interconnecting or proximate areas.

Rosenberg's goanna (*Varanus rosenbergi*) was not identified within the Study Area, despite extensive, seasonal surveys. The Study Area does not contain a significant area of known habitat for this species, and it is considered unlikely that this species is present within the Study Area.

Records of this species occur in general clusters, concentrated on the Sydney sandstone, south to Wollongong, Nowra, Canberra and the southern highlands (DEC 2006av). The western boundary to these records is located along the edge of the Great Dividing Range, within the large Blue Mountains and Wollemi National Parks.

A significant area of known habitat for this species will not be modified or removed, or isolated from currently interconnecting or proximate areas as a result of the Anvil Hill Project.

c) Whether the species, or its habitat, are adequately represented in conservation reserves (or other similar protected areas) in the region.

Three records of Rosenberg's goanna (*Varanus rosenbergi*) have been recorded within Wollemi National Park (DEC 2006av). Given that this species has only been recorded within one conservation reserve within the region, it is unlikely that this species is adequately protected.

d) Whether the species is at the limit of its known distribution.

This species is known to occur on the Sydney Sandstone in Wollemi National Park to the north-west of Sydney, in the Goulburn and ACT regions and near Cooma in the south. There are records from the south west slopes near Khancoban and Tooma River. Also occurs in South Australia and Western Australia (DEC 2006av). Isolated populations occur in Victoria and coastal NSW (Cogger 1994). A record of this species from the Study Area would represent the northern-most record of this species fin New South Wales, as well as the first record from the Hunter Valley.

4. Pale-headed snake – *Hoplocephalus bitorquatus*

The pale-headed snake (*Hoplocephalus bitorquatus*) is a medium-sized largely tree-dwelling snake to 90 cm long (DEC 2006aw). This species has a patchy distribution along the coast, ranges and western slopes from north of Sydney to Cape York Peninsula (Cogger 1994). In NSW it occurs from the coast to the western side of the Great Divide as far south as Tuggerah (DEC 2006aw). Habitat for this species ranges from dry eucalypt forests and woodlands and cypress woodland (DEC 2006aw), to rainforest and wet sclerophyll forest (Cogger 1994). In such habitats, it is known to favour streamside areas (DEC 2006aw). During the day it shelters between loose bark and tree trunks or in hollows in dead trees (DEC 2006aw). The pale-headed snake is live-bearing, with an average of 5 young (Cogger 1994). Frogs are the main prey of this species, however lizards and small mammals are also taken (DEC 2006aw).

a) Whether the life cycle of the species is likely to be disrupted such that a local viable population of the species is likely to be placed at risk of extinction.

The pale-headed snake (*Hoplocephalus bitorquatus*) was not identified within the Study Area, despite extensive, seasonal surveys. It is considered that a local viable population of this species is not likely to be present within the Study Area.

The Anvil Hill Project is unlikely to disrupt a local viable population of the species, such that the species is likely to be placed at risk of extinction.

b) In relation to the regional distribution of the habitat of the threatened species, whether a significant area of known habitat is to be modified or removed, or isolated from currently interconnecting or proximate areas.

The pale-headed snake (*Hoplocephalus bitorquatus*) was not identified within the Study Area, despite extensive, seasonal surveys. The Study Area does not contain a significant area of known habitat for this species, and it is considered unlikely that this species is present within the Study Area.

Within the Hunter region, one record of this species has been documented from Paterson, north of Maitland (DEC 2006aw).

A significant area of known habitat for this species will not be modified or removed, or isolated from currently interconnecting or proximate areas as a result of the Anvil Hill Project.

c) Whether the species, or its habitat, are adequately represented in conservation reserves (or other similar protected areas) in the region.

There have been no sightings of the pale-headed snake (*Hoplocephalus bitorquatus*) recorded within any of the nine conservation reserves identified within the region surrounding the Study Area. As such, it is unlikely that this species is adequately represented in conservation reserves within the region.

d) Whether the species is at the limit of its known distribution.

This species has a patchy distribution along the coast, ranges and western slopes from north of Sydney to Cape York Peninsula (Cogger 1994). In NSW it occurs from the coast to the western side of the Great Divide as far south as Tuggerah (DEC 2006aw). A record of this species from the Study Area would represent a rare record from the southern parts of its distribution.

5. Broad-headed snake – *Hoplocephalus bungaroides*

The broad-headed snake (*Hoplocephalus bungaroides*) is a nocturnal species, with an average length of about 60 cm, with a maximum of around 150 cm (DEC 2006ax). This species is largely confined to Triassic sandstones, including the Hawkesbury, Narellan and Shoalhaven formations, within the coast and ranges in an area within approximately 250 kilometres of Sydney (DEC 2006ax). This range extends from Wollemi National Park to the eastern edge of the Clyde River Catchment, near Bateman's Bay (Swan et al 2004). This species appears to prefer sites where exposed sandstone outcrops and benches occur, particularly in woodland and heath vegetation. This species is known to shelter in rock crevices and under flat sandstone rocks on exposed cliff edges during autumn, winter and spring (DEC 2006ax). In summer, however this species will move from the sandstone rocks to shelters in hollows in large trees within 200 metres of escarpments in summer. The broad-headed snake feeds mostly on geckos and small skinks, however will also eat frogs and small mammals occasionally.

a) Whether the life cycle of the species is likely to be disrupted such that a local viable population of the species is likely to be placed at risk of extinction.

The broad-headed snake (*Hoplocephalus bungaroides*) was not identified within the Study Area, despite extensive, seasonal surveys. It is considered that a local viable population of this species is not likely to be present within the Study Area.

The Anvil Hill Project is unlikely to disrupt a local viable population of the species, such that the species is likely to be placed at risk of extinction.

b) In relation to the regional distribution of the habitat of the threatened species, whether a significant area of known habitat is to be modified or removed, or isolated from currently interconnecting or proximate areas.

The broad-headed snake (*Hoplocephalus bungaroides*) was not identified within the Study Area, despite extensive, seasonal surveys. The Study Area does not contain a significant area of known habitat for this species, and it is considered unlikely that this species is present within the Study Area.

This species has a concentrated distribution, restricted to Wollemi National Park in the north, and Morton National Park in the south. There are no records of this species in proximity to the Study Area.

A significant area of known habitat for this species will not be modified or removed, or isolated from currently interconnecting or proximate areas as a result of the Anvil Hill Project.

c) Whether the species, or its habitat, are adequately represented in conservation reserves (or other similar protected areas) in the region.

There are five records of the broad-headed snake (*Hoplocephalus bungaroides*) within Wollemi National Park (DEC 2006ax). Given that this species has only been recorded within one conservation reserve within the region, it is unlikely that this species is adequately protected.

d) Whether the species is at the limit of its known distribution.

This species is largely confined to Triassic sandstones, including the Hawkesbury, Narellan and Shoalhaven formations, within the coast and ranges in an area within approximately 250 kilometres of Sydney (DEC 2006ax). This range extends from Wollemi National Park to the eastern edge of the Clyde River Catchment, near Bateman's Bay (Swan et al 2004). A record of this species from the Study Area would represent the northern-most record of this species, as well as the only record of this species from the Hunter Valley.

6. Osprey – *Pandion haliaetus*

The osprey (*Pandion halieatus*) has a distribution along the majority of the eastern coastline, however is absent from Tasmania and rare in Victoria (Debus 2001). It is common around the northern coast, especially on rocky shorelines, islands and reefs (DEC 2006ay). The species is uncommon to rare or absent from closely settled parts of south-eastern Australia. Habitat for this species includes inshore coastal and estuarine waters, and occasionally inland rivers and lakes (Debus 2001). This species feeds mainly on fish, however also takes crustaceans, reptiles, small mammals or birds (Debus 2001). Breeding occurs from July to September and nests are often in dead trees and on headlands and rocky islands (Hollands 2003). Nests are re-used for many years (Hollands 2003), and are usually within one kilometre of the ocean (DEC 2006ay).

a) Whether the life cycle of the species is likely to be disrupted such that a local viable population of the species is likely to be placed at risk of extinction.

The osprey (*Pandion halieatus*) was not identified within the Study Area by Umwelt, despite extensive, seasonal surveys. However, Abel Ecology (2005) has a record of this species from the adjoining Envirofund site. This species is identified within the "Observed Fauna" list of the report, however no further details of this species are provided within the survey results or discussion sections of the report.

As this is the only record of this species from the local area, it is likely that this record was of an individual travelling through the local area. There are very few records of this species from inland areas of NSW, and those few records come from large inland waterbodies such as the Macquarie Marshes and Lake Cowal. It is unlikely that this species is resident within the Study Area. Despite this single record, it is considered that a local viable population of this species is not likely to be present within the Study Area.

The Anvil Hill Project is unlikely to disrupt a local viable population of the species, such that the species is likely to be placed at risk of extinction.

b) In relation to the regional distribution of the habitat of the threatened species, whether a significant area of known habitat is to be modified or removed, or isolated from currently interconnecting or proximate areas.

The osprey (*Pandion halieatus*) was not identified by Umwelt within the Study Area, however was recorded by Abel Ecology (2005) within the adjoining Envirofund site. Despite this record, it is not considered that the Study Area (or surrounds) contains a significant area of known habitat for this species.

There are no records of this species in the mid to upper Hunter Valley. The nearest records of this species to the Study Area come from the coastal areas of the Hunter Valley, near and around Newcastle (DEC 2006ay).

A significant area of known habitat for this species will not be modified or removed, or isolated from currently interconnecting or proximate areas as a result of the Anvil Hill Project.

c) Whether the species, or its habitat, are adequately represented in conservation reserves (or other similar protected areas) in the region.

There have been no sightings of the osprey (*Pandion halieatus*) recorded within any of the nine conservation reserves identified within the region surrounding the Study Area. As such, it is unlikely that this species is adequately represented in conservation reserves within the region.

d) Whether the species is at the limit of its known distribution.

The osprey (*Pandion halieatus*) has a distribution along the majority of the eastern coastline, however is absent from Tasmania and rare in Victoria (Debus 2001). They are common around the northern coast, especially on rocky shorelines, islands and reefs (DEC 2006ay). The species is uncommon to rare or absent from closely settled parts of south-eastern Australia. The record of this species near to the Study Area is a highly unusual inland record for this species, particularly as there are few large inland waterbodies in the local area. Despite this, this record does not represent an expansion of the known distribution of this species, rather a rare inland record, particularly in the Hunter Valley.

7. Square-tailed kite – *Lophoictinia isura*

The square-tailed kite (*Lophoictinia isura*) ranges along coastal and sub coastal areas from south-western to northern Australia, Queensland, NSW and Victoria. In NSW, scattered records of the species throughout the state indicate that the species is a regular resident in the north, north-east and along the major west-flowing river systems (DEC 2006az). It is a summer breeding migrant to the south-east, including the NSW south coast, arriving in September and leaving by March (DEC 2006az). The migration appears to involve southerly breeding birds moving north to winter in the tropics (Debus 2001). Records exist from the north and north east, along the Barwon, Culgoa, Darling and Murray rivers, and in the Paroo region (NPWS 1999d). This species is usually recorded within 300 kilometres of the coast (Hollands 2003). This kite is found in a variety of timbered habitats including dry woodlands and open forests, showing a particular preference for timbered watercourses (DEC 2006az). In arid north-western NSW, it has been observed in stony country with a ground cover of chenopods and grasses, open acacia scrub and patches of low open eucalypt woodland (DEC 2006az). Breeding is from July to February, with nest sites generally located along or near watercourses, in a fork or on large horizontal limbs (DEC 2006az). This species appears to occupy large hunting ranges of more than 100 km^2 (DEC 2006az). It is a specialist hunter of passerines, especially honeyeaters, and most particularly nestlings, and insects in the tree canopy, picking most prey items from the outer foliage (DEC 2006az).

a) Whether the life cycle of the species is likely to be disrupted such that a local viable population of the species is likely to be placed at risk of extinction.

The square-tailed kite (*Lophoictinia isura*) was not identified within the Study Area by Umwelt, despite extensive, seasonal surveys. However, Abel Ecology (2005) has a record of this species from the adjoining Envirofund site. This species is identified from this property within the “Observed Fauna” list of the report, however no further details of this species are provided within the survey results or discussion sections of the report. As this is the only record of this species from the local area, it is likely that this record was of an individual occasionally using the local area as part of its very large hunting range. It is unlikely that this species is resident within the Study Area. Despite this single record, it is considered that a local viable population of this species is not likely to be present within the Study Area.

The Anvil Hill Project is unlikely to disrupt a local viable population of the species, such that the species is likely to be placed at risk of extinction.

b) In relation to the regional distribution of the habitat of the threatened species, whether a significant area of known habitat is to be modified or removed, or isolated from currently interconnecting or proximate areas.

The square-tailed kite (*Lophoictinia isura*) was not identified by Umwelt within the Study Area, however was recorded by Abel Ecology (2005) within the adjoining Envirofund site. Despite this record, it is not considered that the Study Area (or surrounds) contains a significant area of known habitat for this species.

There are not a large number of records of this species from the Hunter Valley. Two records exist from the coastal areas of Newcastle, and one record exists from near Lake Glenbawn, near Aberdeen. Other records exist further inland, near Gunnedah and Coonabarabran. There are also a number of records of this species from the western edges of Wollemi and Goulburn River National Parks.

A significant area of known habitat for this species will not be modified or removed, or isolated from currently interconnecting or proximate areas as a result of the Anvil Hill Project.

c) Whether the species, or its habitat, are adequately represented in conservation reserves (or other similar protected areas) in the region.

One record of the square-tailed kite (*Lophoictinia isura*) is documented for Goulburn River National Park (DEC 2006az) and three records of this species are known from Wollemi National Park (DEC 2006az).

Although present within two of the larger national parks within the region, the number of recorded sightings of the square-tailed kite (*Lophoictinia isura*) is very low. As such, it is unlikely that this species is adequately protected within conservation reserves in the region.

d) Whether the species is at the limit of its known distribution.

The square-tailed kite (*Lophoictinia isura*) ranges along coastal and sub coastal areas from south-western to northern Australia, Queensland, NSW and Victoria. In NSW, scattered records of the species throughout the state indicate that the species is a regular resident in the north, north-east and along the major west-flowing river systems (DEC 2006az). A record of this species from the Study Area would not result in an expansion to its known distribution.

8. Red goshawk – *Erythrotriorchis radiatus*

The red goshawk (*Erythrotriorchis radiatus*) has been recorded from across northern Australia, south through eastern Queensland to far north-east NSW. The species is very rare in NSW. Most records are from the Clarence River Catchment, with a few about the lower Richmond and Tweed Rivers (DEC 2006ba). In NSW, preferred habitat is mixed tropical rainforest Melaleuca Swamp Forest and Open Eucalypt Forest along coastal rivers, often in rugged terrain (NPWS 1999e). It favours patches of dense forest interspersed with open woodland or cleared land and often hunts along forest edges and ecotones (DEC 2006ba). Habitats are generally close to permanent bodies of freshwater, nest sites being only up to 1 kilometre away from such water bodies. Nests are positioned in the tallest tree in the landscape, and are an untidy construction of sticks positioned in a fork of a tree (NPWS 1999e). Breeding occurs from April to September (Pizzey & Knight 1997).

a) Whether the life cycle of the species is likely to be disrupted such that a local viable population of the species is likely to be placed at risk of extinction.

The red goshawk (*Erythrotriorchis radiatus*) was not identified within the Study Area, despite extensive, seasonal surveys. It is considered that a local viable population of this species is not likely to be present within the Study Area.

The Anvil Hill Project is unlikely to disrupt a local viable population of the species, such that the species is likely to be placed at risk of extinction.

b) In relation to the regional distribution of the habitat of the threatened species, whether a significant area of known habitat is to be modified or removed, or isolated from currently interconnecting or proximate areas.

The red goshawk (*Erythrotriorchis radiatus*) was not identified within the Study Area, despite extensive, seasonal surveys. The Study Area does not contain a significant area of known habitat for this species, and it is considered unlikely that this species is present within the Study Area.

Records of this species within New South Wales are concentrated in the north eastern corner of the state. There are a small number of scattered records of this species from the Hunter Valley, these being near to Cessnock, Scone, Singleton and Warrah Creek (DEC 2006ba).

A significant area of known habitat for this species will not be modified or removed, or isolated from currently interconnecting or proximate areas as a result of the Anvil Hill Project.

c) Whether the species, or its habitat, are adequately represented in conservation reserves (or other similar protected areas) in the region.

There have been no sightings of the red goshawk (*Erythrotriorchis radiatus*) recorded within any of the nine conservation reserves identified within the region surrounding the

Study Area. As such, it is unlikely that this species is adequately represented in conservation reserves within the region.

d) Whether the species is at the limit of its known distribution.

The red goshawk (*Erythrotriorchis radiatus*) has been recorded from across northern Australia, south through eastern Queensland to far north-east NSW. The species is very rare in NSW. Most records are from the Clarence River Catchment, with a few about the lower Richmond and Tweed Rivers (DEC 2006ba). AS record of this species from the Study Area would represent one of the few records of this species within the Hunter Valley, however would not represent an extension to the known range of this species in New South Wales.

9. Grey falcon – *Falco hypoleucos*

The grey falcon (*Falco hypoleucos*) occurs in arid and semi-arid Australia, including the Murray-Darling basin, Eyre basin, central Australia and Western Australia where there is average annual rainfall of less than 500 mm (Garnett and Crowley 2000). Within NSW the species is found within the Murray-Darling basin and is occasionally recorded east of the Great Dividing Range (DEC 2006bb). It is usually restricted to shrubland, grassland and wooded watercourses of arid and semi-arid regions, although it is occasionally found in open woodlands near the coast, and also occurs near wetlands where surface water attracts prey (DEC 2006bb). The species is found in timbered lowland plains, particularly acacia shrublands, crossed by tree-lined watercourses (Garnett and Crowley 2000). It hunts far out into treeless areas and frequents tussock grasslands and open woodland, especially in winter (Garnett and Crowley 2000). The species nests in the old nests of other birds, particularly those of other raptors and the nests chosen are usually in the tallest trees along watercourses, generally river red gum (*Eucalyptus camaldulensis*) (Garnett and Crowley 2000). The peak laying season is in late winter and early spring (DEC 2006bb).

a) Whether the life cycle of the species is likely to be disrupted such that a local viable population of the species is likely to be placed at risk of extinction.

The grey falcon (*Falco hypoleucos*) was not identified within the Study Area, despite extensive, seasonal surveys. It is considered that a local viable population of this species is not likely to be present within the Study Area.

The Anvil Hill Project is unlikely to disrupt a local viable population of the species, such that the species is likely to be placed at risk of extinction.

b) In relation to the regional distribution of the habitat of the threatened species, whether a significant area of known habitat is to be modified or removed, or isolated from currently interconnecting or proximate areas.

The grey falcon (*Falco hypoleucos*) was not identified within the Study Area, despite extensive, seasonal surveys. The Study Area does not contain a significant area of known habitat for this species, and it is considered unlikely that this species is present within the Study Area.

This species is very rare in the Hunter Valley, with one record from Paterson and one from further west near Gilgandra (DEC 2006bb). The majority of records for this species occur further west, in the arid regions of New South Wales.

A significant area of known habitat for this species will not be modified or removed, or isolated from currently interconnecting or proximate areas as a result of the Anvil Hill Project.

c) Whether the species, or its habitat, are adequately represented in conservation reserves (or other similar protected areas) in the region.

There have been no sightings of the grey falcon (*Falco hypoleucos*) recorded within any of the nine conservation reserves identified within the region surrounding the Study Area. As such, it is unlikely that this species is adequately represented in conservation reserves within the region.

d) Whether the species is at the limit of its known distribution.

The grey falcon (*Falco hypoleucos*) occurs in arid and semi-arid Australia, including the Murray-Darling basin, Eyre basin, central Australia and Western Australia where there is average annual rainfall of less than 500 mm (Garnett and Crowley 2000). Within NSW the species is found within the Murray-Darling basin and is occasionally recorded east of the Great Dividing Range (DEC 2006bb). A record of this species from the Study Area would represent one of the very rare records of this species within the Hunter Valley, however would not represent an extension to the known range of this species.

10. Red-backed button-quail – *Turnix maculosa*

In Australia, the species has a largely coastal and sub-coastal range from the Kimberley region, Western Australia, through the Northern Territory, Queensland and NSW (NSW Scientific Committee 2005c). In NSW, the majority of red-backed button-quail (*Turnix maculosa*) records are from the North Coast Bioregion with a small number of records south as far as Sydney. Three outlying records are known from western NSW. This species inhabits grasslands, woodlands and cropped lands of warm temperate areas that annually receive 400 mm or more of summer rain (NSW Scientific Committee 2005c). It appears to prefer sites near water, including grasslands and sedgelands near creeks, swamps and springs, and wetlands. Breeding is usually in dense grass near water, and nests are made in a shallow depression sparsely lined with grass and ground litter (NSW Scientific Committee 2005c). This is a cryptic species and its specific ecology is poorly documented. It is nocturnal and crepuscular and feeds on insects and seeds (NSW Scientific Committee 2005c). It normally hides and freezes rather than flushing, although individuals will fly for short distances before dropping back to cover. Red-backed button-quail may be encountered individually, in pairs or in small family groups.

a) Whether the life cycle of the species is likely to be disrupted such that a local viable population of the species is likely to be placed at risk of extinction.

The red-backed button-quail (*Turnix maculosa*) was not identified within the Study Area, despite extensive, seasonal surveys. It is considered that a local viable population of this species is not likely to be present within the Study Area.

The Anvil Hill Project is unlikely to disrupt a local viable population of the species, such that the species is likely to be placed at risk of extinction.

b) In relation to the regional distribution of the habitat of the threatened species, whether a significant area of known habitat is to be modified or removed, or isolated from currently interconnecting or proximate areas.

The red-backed button-quail (*Turnix maculosa*) was not identified within the Study Area, despite extensive, seasonal surveys. The Study Area does not contain a significant area of known habitat for this species, and it is considered unlikely that this species is present within the Study Area.

There are very few records of this species within New South Wales. Most records occur in the north eastern corner of the state, with one record near Singleton, and another near Mangrove Mountain, Gosford (DEC 2006ce).

A significant area of known habitat for this species will not be modified or removed, or isolated from currently interconnecting or proximate areas as a result of the Anvil Hill Project.

c) Whether the species, or its habitat, are adequately represented in conservation reserves (or other similar protected areas) in the region.

There have been no sightings of the red-backed button-quail (*Turnix maculosa*) recorded within any of the nine conservation reserves identified within the region surrounding the Study Area. As such, it is unlikely that this species is adequately represented in conservation reserves within the region.

d) Whether the species is at the limit of its known distribution.

In NSW, the majority of red-backed button-quail (*Turnix maculosa*) records are from the North Coast Bioregion with a small number of records south as far as Sydney. Three outlying records are known from western NSW. While there is one record of this species near Singleton, a record of this species in the Study Area would represent one of the very rare records within New South Wales, and one of only two records in the Hunter Valley. A record from the Study Area would also represent the western-most record of this species in New South Wales.

11. Bush stone-curlew – *Burhinus grallarius*

The bush stone-curlew (*Burhinus grallarius*) is found throughout Australia except for the central southern coast and inland, the far south-east corner, and Tasmania. Only in northern Australia is it still common, however, and in the south-east it is either rare or extinct throughout its former range (DEC 2006bc). The current distribution of this species in NSW is patchy and scattered, with small, isolated populations recorded from the Western Slopes and Plains, the Riverina, and scattered coastal areas between the Queensland border and Sydney (NSW Scientific Committee 199d). Coastal areas with identified populations include Pittwater/Brisbane Waters area, Port Stephens, Valla/Coffs Harbour, Grafton/Yamba and Murwillumbah/Pottsville (NSW Scientific Committee 1999d). Habitat for this species includes open woodland with a ground cover of short sparse grass and no or few shrubs (NSW NPWS 2003). In coastal areas, swamp oak groves, saltmarsh, *Melaleuca* woodlands and mangroves provide habitat. In such areas, they have been recorded from residential gardens, and on playing fields (NSW NPWS 2003). Daytime roost sites are generally in woodland among fallen timber where there is good visibility of the surrounding area. At night, birds will travel up to 3 kilometres from the roost site to paddocks, swamps, or woodland feeding areas (NSW Scientific Committee 1999d). This species nests on the ground, generally near timber for cover and camouflage (NSW Scientific Committee 1999d). This is a generally nocturnal species, whose characteristic wailing call is most common on moonlit nights (NSW Scientific Committee 1999d). They nest on the ground in a scrape or small bare patch. Two eggs are laid in spring and early summer (DEC 2006bc).

a) Whether the life cycle of the species is likely to be disrupted such that a local viable population of the species is likely to be placed at risk of extinction.

The bush-stone curlew (*Burhinus grallarius*) was not identified within the Study Area, despite extensive, seasonal surveys. It is considered that a local viable population of this species is not likely to be present within the Study Area.

The Anvil Hill Project is unlikely to disrupt a local viable population of the species, such that the species is likely to be placed at risk of extinction.

b) In relation to the regional distribution of the habitat of the threatened species, whether a significant area of known habitat is to be modified or removed, or isolated from currently interconnecting or proximate areas.

The bush stone-curlew (*Burhinus grallarius*) was not identified within the Study Area, despite extensive, seasonal surveys. The Study Area does not contain a significant area of known habitat for this species, and it is considered unlikely that this species is present within the Study Area.

There are a small number of records of this species from the Hunter Valley, with most of these being from the Nelson Bay area, one from Newcastle, one from Paterson and a final record from Manobalai Nature Reserve, to the west of the Study Area (DEC 2006).

A significant area of known habitat for this species will not be modified or removed, or isolated from currently interconnecting or proximate areas as a result of the Anvil Hill Project.

c) Whether the species, or its habitat, are adequately represented in conservation reserves (or other similar protected areas) in the region.

There has been only one record of the bush stone-curlew (*Burhinus grallarius*) within the nine conservation reserves identified within the region surrounding the Study Area. This record is located from Manobalai Nature Reserve, to the west of the Study Area. It is unlikely that this species is adequately represented in conservation reserves within the region.

d) Whether the species is at the limit of its known distribution.

The current distribution of this species in NSW is patchy and scattered, with small, isolated populations recorded from the Western Slopes and Plains, the Riverina, and scattered coastal areas between the Queensland border and Sydney (NSW NPWS 2003). Coastal areas with identified populations include Pittwater/Brisbane Waters area, Port Stephens, Valla / Coffs Harbour, Grafton/Yamba and Murwillumbah/Pottsville (NSW NPWS 2003). A record of this species from the Study Area would represent one of the few records of this species from the Hunter Valley, however would not represent an extension to the known distribution of this species.

12. Gang-gang cockatoo – *Callocephalon fimbriatum*

The gang-gang cockatoo (*Callocephalon fimbriatum*) is distributed from southern Victoria through south- and central-eastern New South Wales. In New South Wales, the gang-gang cockatoo is distributed from the south-east coast to the Hunter region, and inland to the Central Tablelands and south-west slopes. Isolated records are known from as far north as Coffs Harbour and as far west as Mudgee and the Australian Capital Territory (NSW Scientific Committee 2004a). In summer, it occupies tall montane forests and woodlands, particularly in heavily timbered and mature wet sclerophyll forests (NSW Scientific Committee 2004a). It may also occur in sub-alpine snow gum (*Eucalyptus pauciflora)* woodland and occasionally in temperate rainforests (NSW Scientific Committee 2004a). In winter, it occurs at lower altitudes in drier, more open eucalypt forests and woodlands, particularly in box-ironbark assemblages, or in dry forest in coastal areas (NSW Scientific Committee 2004a). At this time it may be observed in urban areas including parks and gardens (NSW Scientific Committee 2004a). The species in general and creches of young birds in particular, undertake nomadic as well as seasonal movements and may occur at apparently random points within its range. Breeding occurs in hollows of tall, mature sclerophyll forests that have a dense understorey, and occasionally in coastal forests. Breeding usually occurs between October and January (NSW Scientific Committee 2004a).

a) Whether the life cycle of the species is likely to be disrupted such that a local viable population of the species is likely to be placed at risk of extinction.

The gang-gang cockatoo (*Callocephalon fimbriatum*) was not recorded within the Study Area, despite extensive, seasonal surveys. The Study Area provides potential habitat for this species in the form of foraging habitat (flowering and budding eucalyptus) and nesting habitat (large hollows). This is a highly conspicuous, characteristic species, and it is likely that it would have been observed during the survey period, if present in the Study Area.

It is considered unlikely that the Anvil Hill Project will result in the disruption of a local viable population of this species, such that it will be placed at risk of extinction.

b) In relation to the regional distribution of the habitat of the threatened species, whether a significant area of known habitat is to be modified or removed, or isolated from currently interconnecting or proximate areas.

There are very few records of this species from the floor of the Hunter Valley, with most records coming from adjoining national parks such as Wollemi, Goulburn River and Barrington Tops (DEC 2006bd). This species is highly mobile, and is likely to make use of habitat within a number of vegetated areas within the region. It is considered that there is not a local viable population of this species centred within the Study Area.

This species was not recorded within the Study Area, despite the presence of potential foraging and nesting habitat. Due to the lack of records for this species from the Study Area (and from the floor of the Hunter Valley in general) (DEC 2006bd), the Study Area does not provide a significant area of known habitat for this species. As the Study Area is not known habitat for this species, the Anvil Hill Project will not modify, remove, or isolate a significant area of known habitat for this species.

c) Whether the species, or its habitat, are adequately represented in conservation reserves (or other similar protected areas) in the region.

There have been 103 records of the gang-gang cockatoo within Wollemi National Park (NPWS Wildlife Atlas Database 2006). In Goulburn River National Park there have been two records documented (NPWS Wildlife Atlas Database 2006).

Despite there being numerous records of the gang-gang cockatoo (*Callocephalon fimbriatum*) within conservation reserves in the region, available habitat for this species has drastically declined due to high rates of land clearance and degradation through mining and agricultural activities. As such, it is probable that this species is adequately protected within conservation reserves in the region.

d) Whether the species is at the limit of its known distribution.

In New South Wales, the gang-gang cockatoo (*Callocephalon fimbriatum*) is distributed from the south-east coast to the Hunter region, and inland to the Central Tablelands and south-west slopes. Isolated records are known from as far north as Coffs Harbour and as far west as Mudgee and the Australian Capital Territory (NSW Scientific Committee 2004a). A record of this species from the Study Area would represent one of the few records of this species from the Hunter Valley, and would be close to the north-west distribution limit of the species.

13. Red-tailed black cockatoo – *Calyptorhynchus banksii*

The red-tailed black-cockatoo (*Calyptorhynchus banksii*) is the most widespread of the black-cockatoos, ranging broadly across much of northern and western Australia as well as western Victoria. In NSW, one population occurs on the north-western slopes and plains but another small isolated population is found in the coastal north-east (DEC 2006be). Red-tailed black-cockatoos are found in a wide variety of habitats. In coastal north-east NSW they have been recorded in dry open forest and areas of mixed rainforest/eucalypt forest (DEC 2006be). This species breeds usually from May to September but may vary in dry inland areas according to rainfall (Beruldsen 2003). This species nests once a year; the nest consists of a very large vertical hollow in the trunk, sometimes in a large limb, of a tall tree at heights up to 25 metres or more above the ground (Beruldsen 2003). Hollows are usually 0.25 to 0.5 metres in internal diameter and one to two metres or more deep. Preferred nesting trees are ones standing on their own in lightly wooded country, or, in forest country, ones standing a little apart giving free flight access through the canopy (Beruldsen 2003). The red-tailed black-cockatoo feeds mainly on tree seeds, like casuarina, and also fruits, honey and insects (DEC 2006be).

a) Whether the life cycle of the species is likely to be disrupted such that a local viable population of the species is likely to be placed at risk of extinction.

The red-tailed black-cockatoo (*Calyptorhynchus banksii*) was not identified within the Study Area, despite extensive, seasonal surveys. It is considered that a local viable population of this species is not likely to be present within the Study Area.

The Anvil Hill Project is unlikely to disrupt a local viable population of the species, such that the species is likely to be placed at risk of extinction.

b) In relation to the regional distribution of the habitat of the threatened species, whether a significant area of known habitat is to be modified or removed, or isolated from currently interconnecting or proximate areas.

The red-tailed black-cockatoo (*Calyptorhynchus banksii*) was not identified within the Study Area, despite extensive, seasonal surveys. The Study Area does not contain a significant area of known habitat for this species, and it is considered unlikely that this species is present within the Study Area.

The distributional pattern of this species is strongly associated with the Darling Riverine Plains bioregion. There are additional records in the north east corner of the state and along the Queensland border (DEC 2006be). There is one record near (but outside of) the Hunter region, this being at Binnaway.

A significant area of known habitat for this species will not be modified or removed, or isolated from currently interconnecting or proximate areas as a result of the Anvil Hill Project.

c) Whether the species, or its habitat, are adequately represented in conservation reserves (or other similar protected areas) in the region.

There have been no sightings of the red-tailed black cockatoo (*Calyptorhynchus banksii*) recorded within any of the nine conservation reserves identified within the region surrounding the Study Area. As such, it is unlikely that this species is adequately represented in conservation reserves within the region.

d) Whether the species is at the limit of its known distribution.

In NSW, one population occurs on the north-western slopes and plains but another small isolated population is found in the coastal north-east (DEC 2006be). A record of this species from the Study Area would represent a very rare record of this species in the eastern parts of its range, and would be the eastern-most record of this species in central New South Wales.

14. Glossy black-cockatoo – *Calyptorhynchus lathami*

The glossy black-cockatoo (*Calyptorhynchus lathami*) is uncommon although widespread throughout suitable forest and woodland habitats, from the central Queensland coast to East Gippsland in Victoria, and inland to the southern tablelands and central western plains of NSW, with a small population in the Riverina (DEC 2006y). An isolated population exists on Kangaroo Island, South Australia. It inhabits open forest and woodlands of the coast and the Great Dividing Range up to 1000 metres in which stands of she-oak species, particularly black sheoak (*Allocasuarina littoralis*), forest sheoak (*Allocasuarina torulosa*) or drooping sheoak (*Allocasuarina verticillata*) occur (DEC 2006y). In the Riverina area, it inhabits open woodlands dominated by belah (*Casuarina cristata*) (DEC 2006y). It is usually seen in pairs or small groups feeding quietly in sheoaks. It feeds almost exclusively on the seeds of several species of sheoak (*Casuarina* and *Allocasuarina* species), shredding the cones with the massive bill (DEC 2006y). This species can be highly selective in its choice of food trees, choosing *Allocasuarina* species that produce seeds with a high nutrient value. They will also eat seeds from eucalypts, angophoras, acacias, cypress pine and hakeas, as well as eating insect larvae (NSW NPWS 1999a). This species is dependent on large hollow-bearing eucalypts for nest sites. One or two eggs are laid between March and August.

a) Whether the life cycle of the species is likely to be disrupted such that a local viable population of the species is likely to be placed at risk of extinction.

The glossy black-cockatoo (*Calyptorhynchus lathami*) was recorded within the Study Area on nine occasions. From an analysis of known records of this species within the Study Area, the Anvil Hill Project will result in the overall loss of 57.6% of potential habitat (vegetation communities where this species was recorded) for this species.

The Study Area provides known specific foraging habitat for this species, in the form of stands of drooping sheoak (*Allocasuarina verticillata*). The majority of these stands are contained within the Drooping Sheoak Woodland vegetation community, however small stands of this species are scattered throughout the Study Area, often occurring within Ironbark Woodland Complex. Such stands are difficult to map individually, as they are often small in size, can be integrated with other vegetation communities and are difficult to separate from adjoining vegetation communities. The results from the condition assessment surveys have identified that drooping sheoak is more common throughout the Study Area than originally thought, particularly within the Proposed Offset Areas. Potential nesting habitat for this species is present within the Study Area, in the form of large hollows. Hollows of this size are most common in the woodland vegetation formations within the Proposed Offset Areas, where density per hectare reaches 14.3. Despite the presence of hollows suitable for this species, no evidence of breeding was observed during surveys of the Study Area.

While the glossy black-cockatoo was recorded during surveys, it is unlikely that the Study Area provides habitat for a resident population of this species. Rather, it is likely that small numbers of this species (as observed during surveys) would use the habitat within the Study Area periodically, as part of a larger foraging range. The highly mobile nature of this species will allow it to make use of a range of habitat within the local area. Despite this mobility, the relative size of the Study Area in relation to other vegetation remnants in the local area suggests it is likely to be an important habitat resource for this species.

The Anvil Hill Project will require the removal of a large area of vegetation containing specific habitat requirements for this species. As the species is likely to be using such resources from a variety of locations within the local area, it is not likely that the species is entirely dependent on resources provided by the Study Area. Given the size of the Proposed Offset Areas and the large amount of specific foraging and potential nesting habitat present, it is not likely that the Anvil Hill Project will disrupt the life cycle of this species, such that a local viable population of this species is likely to be placed at risk of extinction.

b) In relation to the regional distribution of the habitat of the threatened species, whether a significant area of known habitat is to be modified or removed, or isolated from currently interconnecting or proximate areas.

There are numerous records of this species from the Hunter Valley, however most records come from nearby large, heavily vegetated conservation reserves such as Goulburn River, Wollemi and Barrington Tops National Parks (DEC 2006y). There is a small concentration of records for this species within the large vegetation remnant (including Manobalai Nature Reserve) to the west of the Study Area (DEC 2006y).

The Anvil Hill Project will require the removal of a large area of vegetation containing specific habitat requirements for this species. As the species is likely to be using such resources from a variety of locations within the local area, it is not likely that the species is entirely dependent on resources provided by the Study Area.

The highly mobile nature of this species is likely to offset any impacts from increased isolation as a result of the Anvil Hill Project. However, the fact that a large proportion of known habitat within the Study Area will be removed suggests that there will be a considerable loss of known foraging and potential nesting habitat to those individuals in the region.

c) Whether the species, or its habitat, are adequately represented in conservation reserves (or other similar protected areas) in the region.

The glossy black-cockatoo (*Calyptorhynchus lathami*) has been recorded in several conservation reserves within the region, comprising Goulburn River National Park (17 records), Wollemi National Park (51 records), Manobalai Nature Reserve (6 records), Towarri National Park (1 record), Wingen Main Nature Reserve (4 records) and Mount Royal National Park (6 records) (DEC 2006y).

Available habitat for this species has drastically declined due to high rates of land clearance and degradation through mining and agricultural activities. Despite this, it is likely that this species or its habitat is adequately protected within conservation reserves in the region.

d) Whether the species is at the limit of its known distribution.

The glossy black-cockatoo (*Calyptorhynchus lathami*) is uncommon although widespread throughout suitable forest and woodland habitats, from the central Queensland coast to East Gippsland in Victoria, and inland to the southern tablelands and central western plains of NSW, with a small population in the Riverina (DEC 2006y). An isolated population exists on Kangaroo Island, South Australia. The records of this species from the Study Area are not at the limit of distribution of this species.

15. Superb parrot – *Polytelis swainsonii*

The superb parrot (*Polytelis swainsonii*) is found in well-watered timber adjacent to streams in the east sector of its range, along the Murrumbigee River valley from Canberra to Hay, occasionally to the Victorian border, and the Castlereagh River and its tributaries, with occasional records as far east as Gunnedah (Namoi River) and as far west as Warren (Macquarie River) (Beruldsen 2003). On the South-western Slopes their core breeding area is roughly bounded by Cowra and Yass in the east, and Grenfell, Cootamundra and Coolac in the west. Birds breeding in this region are mainly absent during winter, when they migrate north to the region of the upper Namoi and Gwydir Rivers. The other main breeding sites are in the Riverina along the corridors of the Murray, Edward and Murrumbidgee Rivers where birds are present all year round (DEC 2006bf). This species is known to inhabit Box-Gum, Box-Cypress-pine and Boree Woodlands and River Red Gum (*Eucalyptus camaldulensis*) Forest. In the Riverina the birds nest in the hollows of large trees (dead or alive) mainly in tall riparian river red gum forest or woodland (DEC 2006bf). On the South West Slopes nest trees can be in open Box-Gum Woodland or isolated paddock trees. Species known to be used are Blakely's red gum (*Eucalyptus blakelyi*), yellow box (*Eucalyptus melliodora*), apple box (*Eucalyptus bridgesiana*) and red box (*Eucalyptus polyanthemos*). Superb parrots (*Polytelis swainsonii*) nest in small colonies, often with more than one nest in a single tree. This species breeds once a year between September and January and may forage up to 10 kilometres from nesting sites, primarily in Grassy Box Woodland. This species feeds in trees and understorey shrubs and on the ground and their diet consists mainly of grass seeds and herbaceous plants. Also eaten are fruits, berries, nectar, buds, flowers, insects and grain (Garnett & Crowley 2000).

a) Whether the life cycle of the species is likely to be disrupted such that a local viable population of the species is likely to be placed at risk of extinction.

The superb parrot (*Polytelis swainsonii*) was not identified within the Study Area, despite extensive, seasonal surveys. It is considered that a local viable population of this species is not likely to be present within the Study Area.

The Anvil Hill Project is unlikely to disrupt a local viable population of the species, such that the species is likely to be placed at risk of extinction.

b) In relation to the regional distribution of the habitat of the threatened species, whether a significant area of known habitat is to be modified or removed, or isolated from currently interconnecting or proximate areas.

The superb parrot (*Polytelis swainsonii*) was not identified within the Study Area, despite extensive, seasonal surveys. The Study Area does not contain a significant area of known habitat for this species, and it is considered unlikely that this species is present within the Study Area.

There are no records of this species from the Hunter Valley. The majority of records of this species are from a broad vertical band to the west of the Great Dividing Range, skirting the western sides of towns such as Coonabarabran, Wellington, Orange and Yass (DEC 2006bf). There is a small pocket of records of this species from the Sydney area.

A significant area of known habitat for this species will not be modified or removed, or isolated from currently interconnecting or proximate areas as a result of the Anvil Hill Project.

c) Whether the species, or its habitat, are adequately represented in conservation reserves (or other similar protected areas) in the region.

There have been no sightings of the superb parrot (*Polytelis swainsonii*) recorded within any of the nine conservation reserves identified within the region surrounding the Study Area. As such, it is unlikely that this species is adequately represented in conservation reserves within the region.

d) Whether the species is at the limit of its known distribution.

The superb parrot (*Polytelis swainsonii*) is found in well-watered timber adjacent to streams in the east sector of the range, along the Murrumbigee River valley from Canberra to Hay, occasionally to the Victorian border, and the Castlereagh River and its tributaries, with occasional records as far east as Gunnedah (Namoi River) and as far west as Warren (Macquarie River) (Beruldsen 2003). On the South-western Slopes their core breeding area is roughly bounded by Cowra and Yass in the east, and Grenfell, Cootamundra and Coolac in the west. Birds breeding in this region are mainly absent during winter, when they migrate north to the region of the upper Namoi and Gwydir Rivers. The other main breeding sites are in the Riverina along the corridors of the Murray, Edward and Murrumbidgee Rivers where birds are present all year round (DEC 2006bf). A record of this species from the Study Area would represent the only record of this species from the Hunter region, and would be one of the few records from the eastern parts of the known distribution.

16. Swift parrot – *Lathamus discolor*

The swift parrot (*Lathamus discolor*) breeds in Tasmania during spring and summer, migrating in the autumn and winter months (mainly May to August) to south-eastern Australia from Victoria and the eastern parts of South Australia to south-east Queensland. In NSW mostly occurs on the coast and south west slopes. Here, it has been recorded from the western slopes region along the inland slopes of the Great Dividing Range, as well as forests along the coastal plains from southern to northern NSW (Swift Parrot Recovery Team 2001). On the mainland they occur in areas where eucalypts are flowering profusely or where there are abundant lerp (from sap-sucking bugs) infestations. Favoured feed trees include winter flowering species such as swamp mahogany (*Eucalyptus robusta*), spotted gum (*Corymbia maculata*), red bloodwood (*Corymbia gummifera*), mugga ironbark (*Eucalyptus sideroxylon*), and white box (*Eucalyptus albens*) (DEC 2006bg). They commonly use lerp infested trees including grey box (*Eucalyptus microcarpa*), grey box (*Eucalyptus moluccana*) and blackbutt (*Eucalyptus pilularis*). Of such species, larger trees bearing more flowers are selected (Swift Parrot Recovery Team 2001). This species is known to return to home foraging sites on a cyclic basis depending on food availability (DEC 2006bg). Following winter they return to Tasmania where they breed from September to January, nesting in old trees with hollows and feeding in forests dominated by Tasmanian blue gum (*Eucalyptus globulus*).

a) Whether the life cycle of the species is likely to be disrupted such that a local viable population of the species is likely to be placed at risk of extinction.

The swift parrot (*Lathamus discolor*) was not recorded within the Study Area, despite extensive, seasonal surveys. The Study Area provides potential foraging habitat for this species in the form of flowering and budding eucalypts. This species does not breed on mainland Australia. Due to the large amounts of seasonal survey completed, it is likely that this species would have been observed if currently present in the Study Area. This is a highly mobile, migratory species, which is likely to make use of habitat within a number of vegetated areas within the region. It is considered that there is not a local viable population of this species centred within the Study Area.

It is considered unlikely that the Anvil Hill Project will result in the disruption of a local viable population of this species, such that it will be placed at risk of extinction.

b) In relation to the regional distribution of the habitat of the threatened species, whether a significant area of known habitat is to be modified or removed, or isolated from currently interconnecting or proximate areas.

There are a number of records of this species within the Hunter Valley, however there are very few records in the vicinity of the Study Area. The majority of the records of this species from the Hunter Valley are from the Cessnock area, and closer to the coast around Dora Creek, Morisset and Wyee (DEC 2006bg).

The Study Area is not known habitat for this species, despite the presence of potential foraging resources for this species. Due to the low numbers of records of this species in the vicinity of the Study Area, the Study Area does not provide known habitat for this species. As the Study Area is not known habitat for this species, the Anvil Hill Project will not modify, remove or isolate a significant area of known habitat for this species.

c) Whether the species, or its habitat, are adequately represented in conservation reserves (or other similar protected areas) in the region.

There are two records of the swift parrot (*Lathamus discolor*) occurring within Wollemi National Park (DEC 2006bg). Given that this species has been recorded in only one conservation reserve within the region, it is unlikely that this species is adequately protected.

d) Whether the species is at the limit of its known distribution.

In NSW, this species mostly occurs on the coast and south west slopes. Here, it has been recorded from the western slopes region along the inland slopes of the Great Dividing Range, as well as forests along the coastal plains from southern to northern NSW (Swift Parrot Recovery Team 2001). A record of this species from the Study Area would be a rare record from the upper Hunter, however would not represent an expansion to the known distribution for this species.

17. Turquoise parrot – *Neophema pulchella*

The turquoise parrot's (*Neophema pulchella*) range extends from southern Queensland through to northern Victoria, from the coastal plains to the western slopes of the Great Dividing Range (DEC 2006z). The turquoise parrot occupies a variety of habitats, primarily eucalypt woodland and open forest near open water and forested hills. It is also found in coastal heath, pasture, roadsides and orchards (Pizzey & Knight 1997). Habitat typically has a dense ground cover and a low understorey of shrubs (NSW NPWS 1999b). Fit feeds primarily on seeds, but may also utilise flowers, nectar, fruits, leaves and scale insects (NSW NPWS 1999b). This species is known to forage in white box (*Eucalyptus albens*), yellow box (*Eucalyptus meliodora*), Blakely's red gum (*Eucalyptus blakelyi*), *Leucopogon microphyllus, Dillwynia* spp*.,* and the introduced sea barley grass (*Hordeum marinum),* saffron thistle *(Carthamnus lanatus)* and small nettle (*Urtica urens*) (NSW NPWS 1999b). Usually seen in pairs or small, possibly family, groups and have also been reported in flocks of up to thirty individuals. It prefers to feed in the shade of a tree and spends most of the day on the ground searching for the seeds of grasses and herbaceous plants, or browsing on vegetable matter (DEC 2006z). It breeds August to December and April to May (Pizzey & Knight). The nest is built in a hollow of a small tree, a stump, fence post or even a hollow log on the ground.

a) Whether the life cycle of the species is likely to be disrupted such that a local viable population of the species is likely to be placed at risk of extinction.

The turquoise parrot (*Neophema pulchella*) was recorded on a single occasion during surveys of the Study Area. From an analysis of known records of this species within the Study Area, the Anvil Hill Project will result in the overall loss of 63% of potential habitat (vegetation communities where this species was recorded) for this species.

The Study Area provides known foraging habitat and potential nesting habitat for this species in the form of small to medium hollows. The majority of hollows of these sizes have been recorded from the riparian vegetation formation of the Proposed Disturbance Area, however the woodland vegetation formation of the Proposed Offset Areas contains relatively high levels of medium sized hollows. No evidence of nesting was observed during surveys of the Study Area.

While the turquoise parrot was recorded during surveys, it is unlikely that the Study Area provides habitat for a resident population of this species. It is likely that this species is a periodic visitor to the Study Area, rather than being a resident species. It is not likely that a local viable population of turquoise parrots is resident or solely reliant on the Study Area. Due to the low numbers recorded from the survey, it is likely that this highly mobile species will not rely solely on the habitat within the Study Area, rather exploiting resources from a number of areas within the local area. It is also not likely that the Study Area is an important area of habitat for this species.

The Anvil Hill Project will require the removal of a large area of vegetation containing specific habitat requirements for this species. As the species is likely to be using such resources from a variety of locations within the local area, it is not likely that the species is entirely dependent on resources provided by the Study Area. However, the fact that a large proportion of known habitat within the Study Area will be removed suggests that there will be a significant loss of known foraging and potential nesting habitat to those turquoise parrots in the region. However, due to the low numbers recorded, it is considered unlikely that the Anvil Hill Project will result in the disruption of a local viable population of this species, such that it will be placed at risk of extinction.

b) In relation to the regional distribution of the habitat of the threatened species, whether a significant area of known habitat is to be modified or removed, or isolated from currently interconnecting or proximate areas.

There are not a large number of records of this species from the Hunter Valley, however there are a small number from the valley floor (DEC 2006). The majority of records of this species from the region are from the large, heavily vegetated conservation reserves such as Goulburn River and Wollemi National Parks (DEC 2006z). There are a small number of records for this species within the large vegetation remnant (including Manobalai Nature Reserve) to the west of the Study Area (DEC 2006z).

The Anvil Hill Project will require the removal of a large area of vegetation containing specific habitat requirements for this species. As the species is likely to be using such resources from a variety of locations within the local area, it is not likely that the species is entirely dependent on resources provided by the Study Area.

Any increased isolation of this habitat as a result of the Anvil Hill Project is likely to be offset somewhat by the highly mobile nature of this species.

While a large proportion of known habitat for this species within the Study Area will be removed, the generalist nature of the habitat requirements of this species suggests that there will not be a significant loss of known foraging and potential nesting habitat to those turquoise parrots in the region. This impact is not likely to disrupt the life cycle of this species, such that a local viable population of this species is likely to be placed at risk of extinction.

c) Whether the species, or its habitat, are adequately represented in conservation reserves (or other similar protected areas) in the region.

Goulburn River National Park has 15 recordings of the turquoise parrot (*Neophema pulchella*), while Wollemi National Park has 46 records (NPWS Wildlife Atlas Database 2006).

Despite there being several records of the turquoise parrot within conservation reserves in the region, available habitat for this species has drastically declined due to high rates of land clearance and degradation through mining and agricultural activities. As such, it is unlikely that this species or its habitat is adequately protected within conservation reserves in the region.

d) Whether the species is at the limit of its known distribution.

The turquoise parrot's (*Neophema pulchella*) range extends from southern Queensland through to northern Victoria, from the coastal plains to the western slopes of the Great Dividing Range (DEC 2006z). The record of this species from the Study Area does not represent an extension to the known distribution of this species within the Hunter Valley, or within New South Wales.

18. Powerful owl – *Ninox strenua*

The powerful owl (*Ninox strenua*) occurs in eastern Australia, mostly on the coastal side of the Great Dividing Range, from south western Victoria to Bowen in Queensland (Garnett & Crowley 2000). In NSW, it is widely distributed throughout the eastern forests from the coast inland to tablelands, with scattered, mostly historical records on the western slopes and plains. It is now uncommon throughout its range where it occurs at low densities (DEC 2006aa). This species inhabits a variety of woodland and open forest habitats, including relatively urbanised sites. The majority of records of this species are from within (or one kilometre from) extensively forested areas, usually on publicly owned land (Kavanagh 2002a). The powerful owl requires large tracts of forest or woodland habitat but can also occur in fragmented or urban landscapes (DEC 2006aa). It roosts by day in dense vegetation comprising species such as turpentine (*Syncarpia glomulifera* subsp. *glomulifera*), black sheoak (*Allocasuarina littoralis*), blackwood (*Acacia melanoxylon*), rough-barked apple (*Angorphora floribunda*), cherry ballart (*Exocarpus cupressiformis*) and a number of eucalypt species (DEC 2006aa). As most prey species require hollows and a shrub layer, these are important habitat components for the owl. This species will defend a large home range of between 800 and 1000 hectares (Kavanagh 2002a). This species feeds mainly on a variety of arboreal marsupials, supplementing with large diurnal birds. It takes few or no ground-dwelling mammals (Kavanagh 2002a). Nests are made in large hollows (at least 0.5 metre deep), in large eucalypts (diameter at breast height of 80-240 cm) that are at least 150 years old (DEC 2006aa). Such trees are usually near riparian zone forest and usually minor drainage lines. Powerful owls show high nest tree fidelity in successive breeding seasons (Kavanagh 2002a). Nesting occurs from late autumn to mid-winter, but is slightly earlier in north-eastern NSW (late summer - mid autumn) (DEC 2006aa). Pairs are monogamous nesting for life (DEC 2006aa). The pair is most vocal when nesting (Debus 1995).

a) Whether the life cycle of the species is likely to be disrupted such that a local viable population of the species is likely to be placed at risk of extinction.

The powerful owl (*Ninox strenua*) was recorded within the Study Area previously on two separate occasions. One of these occasions was by T Peake in 1999, where a single powerful owl was accidentally flushed from a cave during diurnal surveys for the Hunter Remnant Vegetation Project (Peake 2006). This record was from an escarpment within the Proposed Offset Areas. The second record of this species was reported by Abel Ecology (2005), who indicate this species from the eastern boundary of the Study Area, to the west of Mangoola Road. It is likely that this record falls within the Proposed Disturbance Area, however it is difficult to interpret from the mapping provided. This record comes from an area dominated primarily by Grassland and Ironbark Woodland Complex. An additional record of this species comes from north of the Study Area, along the Wybong Post Office Road. Despite detailed, seasonal surveys of the Study Area, this species was not recorded by Umwelt surveyors. A number of surveys were completed during the breeding season, when this species is known to be most vocal, and responsive to call playback surveys.

The records of this species within the Study Area may represent a solitary bird that uses the Study Area periodically as part of a larger home range. There is also the potential that the records represent a pair, however the large amount of survey completed for the Anvil Hill Project is likely to have detected at least one of these birds if they (it) was resident within, or making use of the Study Area at the time of survey. As multiple field surveys were completed during times when this species is most responsive to call playback (breeding season), it is likely that this species is not currently residing within the Study Area, rather using the Study Area periodically as part of a larger home range. Return visits to the cave where the species was roosting failed to make additional records of the species.

The Study Area provides known foraging habitat for this species, as well as potential nesting habitat in the form of large hollows. Hollows of this size are most common in the woodland vegetation formations within the Proposed Offset Areas, where density per hectare is 14.3. Notably, this species was recorded roosting within a cave (T Peake unpub. data). Such roosting is not commonly recorded, and may be due to a lack of suitable dense foliage clumps typically chosen by this species for daytime roosting. No caves were recorded within the Proposed Disturbance Area.

The Anvil Hill Project will result in the removal of a large area of known habitat for this species, as well as its prey species within the Study Area. This will include specific habitat requirements such as large hollows for breeding, as well as for its prey species (small to medium hollows). This will also serve to increase the existing isolation of the Study Area from areas of nearby or interconnecting vegetation. While this impact will be partly offset by the high degree of mobility of the powerful owl, this will not be the case for its prey species, whose ability to disperse across fragmented landscapes is highly restricted.

As it is not considered that the powerful owl is resident, or entirely dependent on habitat within the Study Area, the potential impact from the Anvil Hill Project is unlikely to disrupt the life cycle of this species, such that a local viable population of this species is likely to be placed at risk of extinction.

b) In relation to the regional distribution of the habitat of the threatened species, whether a significant area of known habitat is to be modified or removed, or isolated from currently interconnecting or proximate areas.

There are a large number of records of this species from the Hunter Valley, however the majority of these are from the coastal (or near coastal) areas, as is typical of this species. There are records of this species from the Upper Hunter, however these are mostly located from the fringing ranges of Barrington Tops National Park and the large vegetation remnant containing Manobalai Nature Reserve. Generally, records for this species in the Hunter do not occur on the valley floor, rather occurring on the bordering large patches of vegetation that are generally publicly owned.

The Anvil Hill Project will require the removal of a large area of vegetation containing specific habitat requirements for this species. As the species is likely to be using such resources from a variety of locations within the local area, it is not likely that it is entirely dependent on resources provided by the Study Area.

The highly mobile nature of this species is likely to offset any impacts from increased isolation as a result of the Anvil Hill Project, however this isolation will pose an impact on its prey species. The fact that a large proportion of known habitat within the Study Area will be removed suggests that there will be a loss of a large amount of known foraging and potential nesting habitat to those powerful owls (*Ninox strenua*) in the region. In relation to the Study Area, this impact is not considered to be significant.

c) Whether the species, or its habitat, are adequately represented in conservation reserves (or other similar protected areas) in the region.

The powerful owl (*Ninox strenua*) has been recorded in Goulburn River National Park (four records), Wollemi National Park (14 records), Mount Royal National Park (six records) and Manobalai Nature Reserve (two records) (DEC 2006aa).

Despite there being several records of the powerful owl within conservation reserves in the region, available habitat for this species has drastically declined due to high rates of land clearance and degradation through mining and agricultural activities. As such, it is unlikely that this species or its habitat is adequately protected within conservation reserves in the region.

d) Whether the species is at the limit of its known distribution.

In NSW, the powerful owl (*Ninox strenua*) is widely distributed throughout the eastern forests from the coast inland to tablelands, with scattered, mostly historical records on the western slopes and plains (DEC 2006aa). The records of this species within the Study Area do not represent an extension to the known distribution of this species in the Hunter Valley, or in New South Wales. It is however, likely to be approaching the western limit of this species in the Hunter Valley. These records do, however, represent one of the few records of this species from the valley floor.

19. Barking owl – *Ninox connivens*

The barking owl (*Ninox connivens*) is distributed sparsely throughout temperate and semi-arid areas of mainland Australia, however is most abundant in the tropical north (Kavanagh 2002a). Most records for this species occur west of the Great Dividing Range (Kavanagh 2004). It has declined across much of its distribution across NSW and now occurs only sparsely. It is most frequently recorded on the western slopes and plains. It is rarely recorded in the far west or in coastal and escarpment forests (DEC 2006cf). Denser vegetation is used occasionally for roosting. During the day they roost along creek lines, usually in tall understorey trees with dense foliage such as *Acacia* and *Casuarina* species, or the dense clumps of canopy leaves in large eucalypts (DEC 2006cf). Habitat for this species includes dry forests and woodlands (Kavanagh 2002a), often in association with hydrological features such as rivers and swamps (Taylor et al. 2002). This species will live alone, or in a pair covering a territory ranging between 30 and 200 hectares (DEC 2006cf). Barking owls have broad diets dominated by ground-dwelling mammals, birds and insects (Kavanagh 2002b). Breeding is strictly seasonal (late winter/early spring), and occurs in hollows of large, old eucalypts including river red gum (*Eucalyptus camaldulensis*), white box (*Eucalyptus albens*), red box (*Eucalyptus polyanthemos*) and Blakely's red gum (*Eucalyptus blakelyi*).

a) Whether the life cycle of the species is likely to be disrupted such that a local viable population of the species is likely to be placed at risk of extinction.

The barking owl (*Ninox connivens*) was recorded on two occasions in the local area by Abel Ecology (2005). One record of this species was reported from the eastern boundary of the Study Area, to the west of Mangoola Road. It is likely that this record falls within or close to the Proposed Disturbance Area, however it is difficult to interpret from the mapping provided. This record comes from an area dominated primarily by Disturbed Grassland and Ironbark Woodland Complex. An additional record of this species comes from the north of the Study Area, along the Wybong Post Office Road.

Despite detailed surveys of the Study Area, this species was not recorded during current surveys completed by Umwelt. The records of this species may be of a single bird, recorded on two occasions that would be using habitat within the region (possibly the Study Area) as part of a home range. There is the potential that the records represent a pair, however the large amount of survey completed for the current Anvil Hill Project is likely to have detected at least one of these birds if they (it) were resident within, or making use of the Study Area at the time of survey. Due to this lack of repeat records, it is likely that the individual recorded is not currently residing within the Study Area, rather using the Study Area periodically as part of a larger home range.

The Study Area provides potential foraging habitat for this species, as well as potential nesting habitat in the form of large hollows. Hollows of this size are most common in the woodland vegetation formations within the Proposed Offset Areas, where density per hectare reaches 14.3.

The Anvil Hill Project will result in the removal of a large area of potential habitat for this species, as well as its prey species within the Study Area. This will include specific habitat requirements for this species (large hollows) as well as for some of its prey species (small to medium hollows). This will also serve to increase the existing isolation of the Study Area from areas of nearby or interconnecting vegetation. While this impact will be partly offset by the high degree of mobility of the barking owl, this will not be the case for some its prey species, whose ability to disperse across fragmented landscapes is highly restricted.

As it is not considered that the barking owl is resident, or entirely dependent on habitat within the Study Area, the potential impact from the Anvil Hill Project is unlikely to disrupt the life cycle of this species, such that a local viable population of this species is likely to be placed at risk of extinction.

b) In relation to the regional distribution of the habitat of the threatened species, whether a significant area of known habitat is to be modified or removed, or isolated from currently interconnecting or proximate areas.

There are a number of records of these species scattered throughout the Hunter Valley. A number of records exist from Wollemi and Goulburn River National Parks, as well as from areas near to Singleton and Paterson, from the valley floor.

The Anvil Hill Project will require the removal of a large area of vegetation containing specific habitat requirements for this species. As the species is likely to be using such resources from a variety of locations within the local area, it is not likely that the species is entirely dependent on resources provided by the Study Area.

The highly mobile nature of this species is likely to offset any impacts from increased isolation as a result of the Anvil Hill Project, however this isolation will pose an impact on its prey species. The fact that a large proportion of known habitat within the Study Area will be removed suggests that there will be a loss of a large amount of known foraging and potential nesting habitat to those barking owls (*Ninox connivens*) in the region. In relation to the Study Area, this impact is not considered to be significant.

c) Whether the species, or its habitat, are adequately represented in conservation reserves (or other similar protected areas) in the region.

There are two records of the barking owl (*Ninox connivens*) from Goulburn River National Park and six records from Wollemi National Park (DEC 2006cf). Although present within two of the larger national parks within the region, the number of recorded sightings of the barking owl is very low. As such, it is unlikely that this species is adequately protected within conservation reserves in the region.

d) Whether the species is at the limit of its known distribution.

The barking owl (*Ninox connivens*) is distributed sparsely throughout temperate and semi-arid areas of mainland Australia, however is most abundant in the tropical north (Kavanagh 2002a). Most records for this species occur west of the Great Dividing Range (Kavanagh 2004). It has declined across much of its distribution across NSW and now occurs only sparsely. It is most frequently recorded on the western slopes and plains. It is rarely recorded in the far west or in coastal and escarpment forests (DEC 2006cf). A record of this species from the Study Area would not be at the distributional limit of the species.

20. Masked owl – *Tyto novaehollandiae*

The masked owl (*Tyto novaehollandiae*) occurs sparsely throughout the continent and nearby islands, including Tasmania and New Guinea (Kavanagh 2002a). Its distribution extends from the coast where it is most abundant to the western plains (DEC 2006ab). This species is generally recorded from open forest habitat with sparse mid-storey but patches of dense, low ground cover. It is also recorded from ecotones between wet and dry eucalypt forest, along minor drainage lines and near boundaries between forest and cleared land (Kavanagh 2004). Home range estimates vary between 800 and 1200 hectares (Kavanagh 2002a). Masked owls nest (and roost) in large hollows of old trees and they also roost among dense foliage in variety of sub-canopy trees (Kavanagh 2004). They have been recorded nesting and roosting in caves. *Tyto* species have a variable breeding season (likely to be in response to prey fluctuations), however are most likely to breed in autumn or winter (Kavanagh 2002a). Masked owls commonly prey on small terrestrial and scansorial mammals, occasionally supplementing with diurnal birds (Kavanagh 2002b).

a) Whether the life cycle of the species is likely to be disrupted such that a local viable population of the species is likely to be placed at risk of extinction.

The masked owl (*Tyto novaehollandiae*) was recorded within the Study Area on two occasions, once by Umwelt, and once by Abel Ecology (2005). An additional record of this species was recorded by Abel Ecology (2005) from within the adjoining Envirofund site. The Abel Ecology record of this species from within the Study Area is likely to fall within the Proposed Offset Areas to the north of the Study Area, however this is difficult to interpret from the mapping provided. This area is dominated by Disturbed Grassland and Slaty Box Woodland. The Umwelt record was from the Ironbark Woodland Complex vegetation community within the Proposed Offset Areas. From an analysis of known records of this species within the Study Area, the Anvil Hill Project will result in the overall loss of 55.4% of potential habitat (vegetation communities where this species was recorded) for this species.

It is likely that the records of this species from the Study Area may represent a single bird that is using the Study Area as part of a larger home range. There is the potential that the records represent a pair, however the large amount of survey completed only detected one of these birds, suggesting only one was present. Due to the lack of repeat records, it is likely that the individual recorded is not currently residing within the Study Area, rather using the Study Area periodically as part of a larger home range. The high degree of mobility of this species will allow it to make use of nesting and foraging habitat across the region.

The Study Area provides known foraging habitat for this species, as well as potential nesting habitat in the form of large hollows. Hollows of this size are most common in the woodland vegetation formations within the Proposed Offset Areas, where density per hectare is 14.3.

The Anvil Hill Project will result in the removal of a large area of known habitat for this species, as well as its prey species within the Study Area. This will include specific habitat requirements for this species (large hollows) as well as for its prey species (small to medium hollows). This will also serve to increase the existing isolation of the Study Area from areas of nearby or interconnecting vegetation. While this impact will be partly offset by the high degree of mobility of the masked owl, this will not be the case for its prey species, whose ability to disperse across fragmented landscapes is highly restricted.

As it is not considered that the masked owl is resident, or entirely dependent on habitat within the Study Area, the potential impact from the Anvil Hill Project is unlikely to disrupt the life cycle of this species, such that a local viable population of this species is likely to be placed at risk of extinction.

b) In relation to the regional distribution of the habitat of the threatened species, whether a significant area of known habitat is to be modified or removed, or isolated from currently interconnecting or proximate areas.

There are a number of records of this species within the Hunter region, particularly in the coastal regions surrounding Newcastle, out to Maitland. From here, records of this species decline to the west, where records become rarer, and generally restricted to large national parks fringing the valley floor. There are two records of this species from the Ravensworth area.

The Anvil Hill Project will require the removal of a large area of vegetation containing specific habitat requirements for this species. As the species is likely to be using such resources from a variety of locations within the local area, it is not likely that it is entirely dependent on resources provided by the Study Area.

The highly mobile nature of this species is likely to offset any impacts from increased isolation as a result of the Anvil Hill Project, however this isolation will pose an impact on its prey species. The fact that a large proportion of known habitat within the Study Area will be removed suggests that there will be a loss of a large amount of known foraging and potential nesting habitat to those masked owls (*Tyto novaehollandiae*) in the region. In relation to the Study Area, this impact is not considered to be significant.

c) Whether the species, or its habitat, are adequately represented in conservation reserves (or other similar protected areas) in the region.

There are two records of the masked owl (*Tyto novaehollandiae*) within Goulburn River National Park, two records within Wollemi National Park and four records within Mount

Royal National Park. Although present within two of the larger national parks within the region, the number of recorded sightings of the masked owl is very low. As such, it is unlikely that this species is adequately protected within conservation reserves in the region

d) Whether the species is at the limit of its known distribution.

The masked owl (*Tyto novaehollandiae*) occurs sparsely throughout the continent and nearby islands, including Tasmania and New Guinea (Kavanagh 2002a). Its distribution extends from the coast where it is most abundant to the western plains (DEC 2006ab). The record of this species from the Study Area represents one of the rare records of this species in the upper Hunter Valley, however does not represent the western limit of the species known distribution.

21. Brown treecreeper – *Climacteris picumnus victoriae*

The brown treecreeper (*Climacteris picumnus victoriae*) is endemic to eastern Australia and occurs in eucalypt forests and woodlands of inland plains and slopes of the Great Dividing Range. It is less commonly found on coastal plains and ranges (DEC 2006ac). The western boundary of the range of brown treecreeper (*Climacteris picumnus victoriae*) runs approximately through Wagga Wagga, Temora, Forbes, Dubbo and Inverell and along this line the subspecies intergrades with the arid zone subspecies of brown treecreeper (*Climacteris picumnus picumnus*) (DEC 2006ac). This species occurs over central NSW, west of the Great Dividing Range and sparsely scattered to the east of the Divide in drier areas such as the Cumberland Plain of Western Sydney, and in parts of the Hunter, Clarence, Richmond and Snowy River valleys (NSW Scientific Committee 2001a). It is found in eucalypt woodlands (including Box-Gum Woodland) and dry open forest of the inland slopes and plains; mainly inhabits woodlands dominated by stringybarks or other rough-barked eucalypts, usually with an open grassy understorey, sometimes with one or more shrub species; also found in mallee and river red gum (*Eucalyptus camaldulensis*) forest bordering wetlands with an open understorey of acacias, saltbush, lignum, cumbungi and grasses; usually not found in woodlands with a dense shrub layer; fallen timber is an important habitat component for foraging; also recorded, though less commonly, in similar woodland habitats on the coastal ranges and plains (DEC 2006ac). This species is sedentary, territorial year-round, although some birds may disperse locally after breeding (DEC 2006ac). The brown treecreeper is gregarious and is usually observed in pairs or small groups of eight to 12 birds; it is active, noisy and conspicuous while foraging on trunks and branches of trees and amongst fallen timber. This species is known to spend more time foraging on the ground and fallen logs than other treecreepers (DEC 2006ac). Hollows in standing dead or live trees and tree stumps are essential for nesting. The species breeds in pairs or co-operatively in territories which range in size from 1.1 to 10.7 ha (mean = 4.4 ha). Each group comprises a breeding pair with retained male offspring and, rarely, retained female offspring. The brown treecreeper is highly sensitive to habitat fragmentation, with disrupted dispersal due to habitat isolation being the primary threat (Walters et al. 1999). Major declines of this species have occurred in remnant vegetation fragments smaller than 300 hectares that have been isolated or fragmented for more than 50 years (DEC 2006ac).

a) Whether the life cycle of the species is likely to be disrupted such that a local viable population of the species is likely to be placed at risk of extinction.

The brown treecreeper (*Climacteris picumnus victoriae*) was recorded within the Study Area on 32 occasions. From an analysis of known records of this species within the Study Area, the Anvil Hill Project will result in the overall loss of 57.7% of potential habitat (vegetation communities where this species was recorded) for this species.

The Study Area provides known foraging habitat for this species, as well as potential breeding habitat in the form of small to medium hollows, which occur most frequently in the riparian vegetation formation of the Proposed Disturbance Area. Despite the presence of hollows suitable for this species, no opportunistic evidence of breeding was observed during surveys of the Study Area.

This is a sedentary and territorial species, occupying home ranges that can range in size from approximately one to 10 hectares in size. When considering the number of records of this species spread across the Study Area, it is likely that there are a number of small sub-populations of this species occurring. These sub-populations are likely to be represented as small family groups with a breeding pair, and some of their offspring. While there would be some interchange of genetic between nearby sub-populations, this species is not able to readily disperse throughout fragmented landscapes.

Given that the Study Area forms part of a large fragment that is already largely isolated from nearby vegetation, it is likely that the brown treecreepers (*Climacteris picumnus victoriae*) within this large fragment form a population that is already facing pressures from isolation and fragmentation. The current degree of isolation of this fragment is likely to be limiting the ability for dispersal and recruitment, thus limiting genetic inflow/outflow for this population.

The likely impact of the Anvil Hill Project will be to further isolate the sub-populations of this species within the Study Area, through direct habitat loss. In particular, the sub-populations within the Proposed Disturbance Area will lose all current habitat, and this, coupled with competitive pressures for the remaining habitat within the Proposed Offset Areas, has the potential to cause local extinctions of sub-populations of this species within the Study Area. This risk of local extinctions will be further exacerbated, if sub-populations within the Proposed Disturbance Area are lost, thus further isolating sub-populations on the outer edges of the Study Area.

The Anvil Hill Project will require the removal of a large area of vegetation containing specific habitat requirements for this species. As this is a sedentary, territorial species with limited dispersal ability, it is likely that this species is not using resources from the local area, rather is confined to the vegetation within the existing remnant. The fact that a large proportion of known habitat within the Study Area will be removed suggests that there will be a significant loss of known foraging and potential nesting habitat to the brown treecreepers within the Study Area. This impact is likely to disrupt the life cycle of this species, such that a local viable population of this species is likely to be placed at risk of extinction.

b) In relation to the regional distribution of the habitat of the threatened species, whether a significant area of known habitat is to be modified or removed, or isolated from currently interconnecting or proximate areas.

There are many records of this eastern subspecies across the Hunter Valley. Clusters of records of this species occur within the Study Area, nearby Manobalai Nature Reserve, Goulburn River National Park, Wollemi National Park and Weston, near Kurri Kurri (DEC 2006ac).

The Anvil Hill Project will require the removal of a large area of vegetation containing specific habitat requirements for this species. As the species is sedentary, territorial and lacks a high degree of mobility, it is likely that the species is entirely dependent on resources provided by the Study Area.

The Anvil Hill Project is likely to exacerbate isolation pressures already operating on this species within the Study Area. The fact that a large proportion of known habitat within the Study Area will be removed suggests that there will be a significant loss of known foraging and potential nesting habitat to those brown treecreepers (*Climacteris picumnus victoriae*) in the Study Area, and region.

c) Whether the species, or its habitat, are adequately represented in conservation reserves (or other similar protected areas) in the region.

The brown treecreeper (*Climacteris picumnus victoriae*) has been recorded in four conservation reserves within the region. These are Goulburn River National Park (25 records), Wollemi National Park (18 records), Manobalai Nature Reserve (four records) and Wingen Main Nature Reserve (one record) (DEC 2006ac).

Despite there being several records of the brown treecreeper within conservation reserves in the region, available habitat for this species has drastically declined due to high rates of land clearance and degradation through mining and agricultural activities. As such, it is unlikely that this species is adequately protected within conservation reserves in the region.

d) Whether the species is at the limit of its known distribution.

The brown treecreeper (*Climacteris picumnus victoriae*) is endemic to eastern Australia and occurs in eucalypt forests and woodlands of inland plains and slopes of the Great Dividing Range. It is less commonly found on coastal plains and ranges (DEC 2006ac). The western boundary of the range of the brown treecreeper runs approximately through Wagga Wagga, Temora, Forbes, Dubbo and Inverell and along this line the subspecies intergrades with the arid zone subspecies of brown treecreeper (*Climacteris picumnus picumnus*) (DEC 2006ac). Records of this species within the Study Area are not at the distributional limit of the species.

22. Regent honeyeater – *Xanthomyza phrygia*

The regent honeyeater (*Xanthomyza phrygia*) mainly inhabits temperate woodlands and open forests of the inland slopes of south-east Australia. Birds are also found in drier coastal woodlands and forests in some years (DEC 2006bh). In NSW the distribution is very patchy and mainly confined to the two main breeding areas (the Capertee Valley and the Bundarra-Barraba region) and surrounding fragmented woodlands. In some years non-breeding flocks converge on flowering coastal woodlands and forests (DEC 2006bh). The species inhabits dry open forest and woodland, particularly Box-Ironbark woodland, and riparian forests of river sheoak (*Casuarina cunninghamiana*). Every few years, non-breeding flocks are seen foraging in flowering coastal swamp mahogany (*Eucalyptus robusta*) and spotted gum (*Corymbia maculata*) forests, particularly on the Central Coast and occasionally on the upper north coast (DEC 2006bh). Birds are occasionally seen on the South Coast. In the last 10 years regent honeyeaters have been recorded in urban areas around Albury where woodland tree species such as mugga ironbark (*Eucalyptus sideroxylon*) and yellow box (*Eucalyptus melliodora*) were planted 20 years ago (DEC 2006bh). The regent honeyeater is a generalist forager, which mainly feeds on the nectar from a wide range of eucalypts and mistletoes. Key eucalypt species include mugga ironbark (*Eucalyptus sideroxylon*), yellow box (*Eucalyptus melliodora*), Blakely's red gum (*Eucalyptus blakelyi*), white box (*Eucalyptus albens*) and swamp mahogany (*Eucalyptus robusta*). The regent honeyeater also utilise: grey box (*Eucalyptus microcarpa*), grey gum (*Eucalyptus punctata*), red box (*Eucalyptus polyanthemos)*, grey box (*Eucalyptus moluccana)*, narrow-leaved ironbark (*Eucalyptus crebra*), *Eucalyptus caleyi*, spotted gum (*Corymbia maculata)*, Mckie’s stringybark (*Eucalyptus mckieana)*, red stringybark (*Eucalyptus macrorhyncha*), silver top stringybark (*Eucalyptus laevopinea)* and rough-barked apple (*Angophora floribunda*). It is likely that movements are dependent on spatial and temporal flowering and other resource patterns. An apparent preference exists for the wettest, most fertile sites within these associations, such as creek flats, river valleys and foothills (Garnet & Crowley 2000). The species breeds between July and January in Box-Ironbark and other temperate woodlands and riparian gallery forest dominated by river sheoak (*Casuarina cunninghamiana*). There are only three known key breeding regions remaining: north-east Victoria (Chiltern-Albury), and in NSW at Capertee Valley and the Bundarra-Barraba region (DEC 2006bh).

a) Whether the life cycle of the species is likely to be disrupted such that a local viable population of the species is likely to be placed at risk of extinction.

The regent honeyeater (*Xanthomyza phrygia*) was not recorded within the Study Area, despite extensive, seasonal surveys. The Study Area provides potential foraging habitat for this species in the form of flowering and budding eucalypts. It also provides potential nesting habitat for this species, although the Study Area does not fall within (or near to) any of the three key breeding areas for this species. Due to the large amounts of seasonal survey completed, it is likely that this species would have been observed if present in the Study Area at the time of survey. This is a highly mobile, migratory species, which is likely to make use of habitat within a number of vegetated areas within the region. It is considered that there is not a local viable population of this species centred within the Study Area.

The regent honeyeater is a well-studied species, with an active recovery team and national recovery plan currently in action. Despite this attention, and the presence of potential habitat, there are not a large number of records of this species in the area.

It is considered unlikely that the Anvil Hill Project will result in the disruption of a local viable population of this species, such that it will be placed at risk of extinction.

b) In relation to the regional distribution of the habitat of the threatened species, whether a significant area of known habitat is to be modified or removed, or isolated from currently interconnecting or proximate areas.

There are a number of records of this species from the Hunter Valley, mainly from the Newcastle and Cessnock regions. There are also records of this species scattered along the edges of the fringing National Parks, such as Wollemi and Goulburn River. Records near to the Study Area occur from Muswellbrook and near to Sandy Hollow.

The Anvil Hill Project is likely to increase the isolation of the remnant, however this impact is likely to be reduced due to the highly mobile nature of this species.

c) Whether the species, or its habitat, are adequately represented in conservation reserves (or other similar protected areas) in the region.

There are 10 records of the regent honeyeater (*Xanthomyza phrygia*) within Goulburn River National Park, and 35 records within Wollemi National Park (DEC 2006bh).

Despite there being several records of the regent honeyeater within conservation reserves in the region, available habitat for this species has drastically declined due to high rates of land clearance and degradation through mining and agricultural activities. As such, it is unlikely that this species is adequately protected within conservation reserves in the region.

d) Whether the species is at the limit of its known distribution.

The regent honeyeater (*Xanthomyza phrygia*) mainly inhabits temperate woodlands and open forests of the inland slopes of south-east Australia. Birds are also found in drier coastal woodlands and forests in some years (DEC 2006bh). In NSW the distribution is very patchy and mainly confined to the two main breeding areas (the Capertee Valley and the Bundarra-Barraba region) and surrounding fragmented woodlands. In some years non-breeding flocks converge on flowering coastal woodlands and forests (DEC 2006bh). A record of this species from the Study Area would not be at the distributional limit of the species.

23. Black-chinned honeyeater – *Melithreptus gularis gularis*

The subspecies is widespread, from the tablelands and western slopes of the Great Dividing Range to the north-west and central-west plains and the Riverina. It is rarely recorded east of the Great Dividing Range, although it is regularly observed from the Richmond River district. It has also been recorded at a few scattered sites in the Hunter, Central Coast and Illawarra regions (DEC 2006bi). In NSW, it is mainly found in woodlands with annual rainfall of 400-700 mm containing box-ironbark associations and river red gum (*Eucalyptus camaldulensis*) (Garnett & Crowley 2000). The species does not persist in remnants less than 200 hectares in area (NSW Scientific Committee 2001d). Black-chinned honeyeaters (*Melithreptus gularis gularis*) occupy mostly upper levels of drier open forests or woodlands dominated by box and ironbark eucalypts, especially mugga ironbark (*Eucalyptus sideroxylon*), white box (*Eucalyptus albens*), grey box (*Eucalyptus microcarpa*), yellow box (*Eucalyptus melliodora*) and forest red gum (*Eucalyptus tereticornis*). It also inhabits open forests of smooth-barked gums, stringybarks, ironbarks and tea-trees (DEC 2006bi). This is a gregarious species, usually seen in pairs and small groups of up to 12 birds. Feeding territories are large making the species locally nomadic. Recent studies have found that the black-chinned honeyeater tends to occur in the largest woodland patches in the landscape as birds forage over large home ranges of at least five hectares. This species moves quickly from tree to tree, foraging rapidly along outer twigs, underside of branches and trunks, probing for insects. Nectar is taken from flowers, and honeydew is gleaned from foliage. It will breed solitarily or co-operatively, with up to five or six adults, from June to December (DEC 2006d).

a) Whether the life cycle of the species is likely to be disrupted such that a local viable population of the species is likely to be placed at risk of extinction.

The black-chinned honeyeater (*Melithreptus gularis gularis*) was not recorded by Umwelt within the Study Area, despite detailed seasonal surveys. This species was, however, reported by Abel Ecology (2005), where the record was sourced from the HLA Envirosciences data (2002). This information could not be confirmed from the HLA data available to Umwelt. The location of the record is unknown.

The Study Area provides potential foraging and breeding habitat for this species. The lack of identification of this species by the Umwelt surveys, despite large amounts of seasonal survey, suggests that there is not likely to be a local viable population centred on the Study Area. This is a highly mobile, migratory species, which is likely to make use of habitat within a number of vegetated areas within the region. It is considered that there is not a local viable population of this species centred within the Study Area.

It is considered unlikely that the Anvil Hill Project will result in the disruption of a local viable population of this species, such that it will be placed at risk of extinction.

b) In relation to the regional distribution of the habitat of the threatened species, whether a significant area of known habitat is to be modified or removed, or isolated from currently interconnecting or proximate areas.

There are a number of records of this species from within the Hunter Valley. Some of these records are centered on the Cessnock and Kurri Kurri areas. Further records of this species occur along the northern and western sections of Wollemi and Goulburn River National Parks. On the valley floor, there are a small number of records of this species from the Ravensworth, Muswellbrook and Wybong areas.

Due to the small number of records of this species within the area, it is unlikely that the Study Area forms an important habitat area for this species. The nature of the Anvil Hill Project is that it is likely to increase the isolation of the remnant, however this impact is likely to be reduced due to the highly mobile nature of this species.

c) Whether the species, or its habitat, are adequately represented in conservation reserves (or other similar protected areas) in the region.

There are four records of the black-chinned honeyeater (*Melithreptus gularis gularis*) for Goulburn River National Park and 22 records for Wollemi National Park (DEC 2006bi).

Despite there being several records of the black-chinned honeyeater within conservation reserves in the region, available habitat for this species has drastically declined due to high rates of land clearance and degradation through mining and agricultural activities. As such, it is unlikely that this species is adequately protected within conservation reserves in the region.

d) Whether the species is at the limit of its known distribution.

The subspecies is widespread, from the tablelands and western slopes of the Great Dividing Range to the north-west and central-west plains and the Riverina. It is rarely recorded east of the Great Dividing Range, although regularly observed from the Richmond River district. It has also been recorded at a few scattered sites in the Hunter, Central Coast and Illawarra regions (DEC 2006bi). A record of this species within the Study Area would not represent the distributional limit of the species.

24. Painted honeyeater – *Grantiella picta*

This species has a sparse distribution ranging from south eastern Australia to north western Queensland and eastern Northern Territory (Garnett & Crowley 2000). The greatest concentrations of records of this species (including almost all breeding records) occur on the inland slopes of the Great Dividing Range in NSW, Victoria and southern Queensland (DEC 2006ag). The painted honeyeater (*Grantiella picta*) is nomadic and occurs at low densities throughout its range (DEC 2006ag). In southern areas, this species migrates north to semi-arid regions in South Australia, and northern Australia after April. Typical habitat for this species includes Boree, Brigalow and Box-Gum Woodlands and Box-Ironbark Forests (DEC 2006ag), particularly those with high concentrations of mistletoes (mainly *Amyema* spp.). It feeds almost exclusively on mistletoe berries, however will take nectar and insects occasionally (Garnett & Crowley 2000). Breeding distribution is often dictated by the presence of suitable mistletoes. Generally, it will nest from spring to autumn in a small, delicate nest hanging within the outer canopy of drooping eucalypts, sheoak, paperbark or mistletoe branches (DEC 2006ag).

a) Whether the life cycle of the species is likely to be disrupted such that a local viable population of the species is likely to be placed at risk of extinction.

The painted honeyeater (*Grantiella picta*) was not recorded within the Study Area, despite extensive, seasonal surveys. However, this species was recorded from Abel Ecology (2005). This record was sourced from the HLA Envirosciences data (HLA Envirosciences 2002A), being from a personal observation from a local landholder. This record was described in this report as a "past record".

The Study Area provides potential foraging habitat for this species in the form of a number of mistletoe species, with high concentrations present in some areas. The Study Area also provides potential nesting habitat for this species. Due to the large amounts of seasonal survey completed, it is likely that this species would have been observed if currently present in the Study Area. This is a highly mobile, partly migratory species, which is likely to make use of habitat within a number of vegetated areas within the region. It is considered that there is not a local viable population of this species centred within the Study Area.

It is considered unlikely that the Anvil Hill Project will result in the disruption of a local viable population of this species, such that it will be placed at risk of extinction.

b) In relation to the regional distribution of the habitat of the threatened species, whether a significant area of known habitat is to be modified or removed, or isolated from currently interconnecting or proximate areas.

There are not a large number of records of this species within the Hunter Valley, however those that do exist are scattered between the valley floor and fringing National Parks. There are small clusters of records further afield from Binnaway State Forest and Munghorn Gap Nature Reserve.

The Anvil Hill Project is likely to increase the isolation of the remnant, however this impact is likely to be reduced due to the highly mobile nature of this species.

c) Whether the species, or its habitat, are adequately represented in conservation reserves (or other similar protected areas) in the region.

There has been one record of the painted honeyeater (*Grantiella picta*) within Wollemi National Park (DEC 2006ag). Given that this species has only been recorded within one conservation reserve within the region, it is not considered that this species is adequately protected.

d) Whether the species is at the limit of its known distribution.

This species has a sparse distribution ranging from south eastern Australia to north western Queensland and eastern Northern Territory (Garnett & Crowley 2000). The greatest concentrations of records of this species (including almost all breeding records) occur on the inland slopes of the Great Dividing Range in NSW, Victoria and southern Queensland (DEC 2006ag). A record of this species from the Study Area would not represent the distributional limit of the species.

25. Speckled warbler – *Pyrrholaemus sagittata*

The speckled warbler (*Pyrrholaemus sagittata*) has a distribution from south-eastern Queensland, through central and eastern NSW to Victoria. In NSW, this species occupies eucalypt and cypress woodlands, generally on the western slopes of the Great Dividing Range. It is rarely recorded from coastal areas (DEC 2006ad). It inhabits woodlands with a grassy understorey, leaf litter and shrub cover, often on ridges or gullies (Garnett & Crowley 2000). This species has also been recorded in cypress woodlands of the northern Riverina and in drier coastal areas such as the Cumberland Plain, Western Sydney and the Hunter and Snowy River valleys (NSW Scientific Committee 2001b). Typical habitat for this species would include scattered native tussock grasses, a sparse shrub layer, some eucalypt regrowth and an open canopy (DEC 2006ad). The species is sedentary, living in pairs or trios and nests on the ground in grass tussocks, dense litter and fallen branches. Home ranges vary from 6-12 hectares (NSW Scientific Committee 2001b). The nest is located in a slight hollow in the ground or the base of a low dense plant, often among fallen branches and other litter (DEC 2006ad). Breeding occurs between August and January, with cooperative breeding occasionally occurring (DEC 2006ad). Barrett et al. (1994) found that the species decreased in abundance as woodland area decreased, and it appears to be extinct in districts where no fragments larger than 100 hectares remain. Speckled warblers often join mixed species feeding flocks in winter, with other species such as yellow-rumped thornbill

(*Acanthiza chrysorrhoa*), buff-rumped thornbill (*Acanthiza reguloides*), brown thornbill (*Acanthiza pusilla*) and striated thornbill (*Acanthiza lineata*) (DEC 2006ad).

a) Whether the life cycle of the species is likely to be disrupted such that a local viable population of the species is likely to be placed at risk of extinction.

The speckled warbler (*Pyrrholaemus sagittata*) was recorded within the Study Area on 32 occasions. From an analysis of known records of this species within the Study Area, the Anvil Hill Project will result in the overall loss of 57.0% of potential habitat (vegetation communities where this species was recorded) for this species.

The Study Area provides known foraging habitat for this species, as well as potential breeding habitat. Despite the presence of potential breeding habitat, no opportunistic evidence of breeding was observed during surveys of the Study Area.

This is a sedentary and territorial species, occupying home ranges that can vary in size from approximately six to 12 hectares. When considering the number of records of this species spread across the Study Area, it is likely that there are a number of small sub-populations of this species occurring within the Study Area. These sub-populations are likely to be represented as small family groups with a breeding pair, and some of their offspring. While it is likely that there would be some interchange of genetic material between nearby sub-populations, this species is not able to readily disperse throughout fragmented landscapes.

Given that the Study Area forms part of a large fragment that is already isolated from nearby vegetation, it is likely that the speckled warblers within this large fragment form a population that is already facing pressures from isolation and fragmentation. The current degree of isolation of this fragment is likely to be limiting the ability for dispersal and recruitment, thus limiting genetic inflow/outflow for this population.

The likely impact of the Anvil Hill Project will be to further isolate the sub-populations of this species within the Study Area. In particular, the sub-populations within the Proposed Disturbance Area will lose all current habitat, and this, coupled with competitive pressures for the remaining habitat within the Proposed Offset Areas, has the potential to cause local extinctions of sub-populations of this species within the Study Area. This risk of local extinctions will be further exacerbated if sub-populations within the central parts of the Study Area are lost, thus further isolating sub-populations on the outer edges of the Study Area.

The Anvil Hill Project will require the removal of a large area of vegetation containing specific habitat requirements for this species. As this is a sedentary, territorial species with limited dispersal ability, it is likely that this species is not using resources from the local area, rather is confined to the vegetation within the existing remnant. The fact that a large proportion of known habitat within the Study Area will be removed suggests that there will be a significant loss of known foraging and potential nesting habitat to the speckled warblers within the Study Area. This impact is likely to disrupt the life cycle of this species, such that a local viable population of this species is likely to be placed at risk of extinction.

b) In relation to the regional distribution of the habitat of the threatened species, whether a significant area of known habitat is to be modified or removed, or isolated from currently interconnecting or proximate areas.

There are a large number of records of this species from the Hunter Valley, including several from the valley floor. However, the majority appear to be from the fringing Wollemi and Goulburn River National Parks, as well as the large vegetated remnants of the Study Area and nearby Manobalai Nature Reserve.

The Anvil Hill Project will require the removal of a large area of vegetation containing specific habitat requirements for this species. As the species is sedentary, territorial and lacks a high degree of mobility, it is likely that the species is entirely dependent on resources provided by the Study Area.

The Anvil Hill Project is likely to exacerbate isolation pressures already being faced by this species within the Study Area. The fact that a large proportion of known habitat within the Study Area will be removed suggests that there will be a significant loss of known foraging and potential nesting habitat to those speckled warblers (*Pyrrholaemus sagittata*) in the Study Area, and region.

c) Whether the species, or its habitat, are adequately represented in conservation reserves (or other similar protected areas) in the region.

The speckled-warbler (*Pyrrholaemus sagittata*) has been recorded within several conservation reserves within the region. These comprise Goulburn River National Park (9 records), Wollemi National Park (16 records), Wingen Maid Nature Reserve (one record), Manobalai Nature Reserve (seven records) and Burning Mountain Nature Reserve (one record) (DEC 2006ad).

Despite there being several records of the speckled warbler within conservation reserves in the region, available habitat for this species has drastically declined due to high rates of land clearance and degradation through mining and agricultural activities. As such, it is unlikely that this species is adequately protected within conservation reserves in the region.

d) Whether the species is at the limit of its known distribution.

The speckled warbler (*Pyrrholaemus sagittata*) has a distribution from south-eastern Queensland, through central and eastern NSW to Victoria. In NSW, this species occupies eucalypt and cypress woodlands, generally on the western slopes of the Great Dividing Range. It is rarely recorded from coastal areas (DEC 2006ad). The record of this species from the Study Area does not represent the distributional limit of the species.

26. Hooded robin (south east form) - *Melanodryas cucullata cucullata*

The species is widespread, found across Australia, except for the driest deserts and the wetter coastal areas - northern and eastern coastal Queensland and Tasmania (DEC 2006ae). The south-eastern form of the hooded robin (*Melanodryas cucullata cucullata*) is found from Brisbane to Adelaide throughout much of inland NSW, with the exception of the north-west. This form occurs throughout NSW except for the north-west, where it intergrades with the hooded robin northern form (*Melanodryas cucullata picata*) (NSW Scientific Committee 2001c). This species prefers lightly wooded country, usually open eucalypt woodland, acacia scrub and mallee, often in or near clearings or open areas. Hooded robins require structurally diverse habitats featuring mature eucalypts, saplings, some small shrubs and a ground layer of moderately tall native grasses (DEC 2006ae). They often perch on low dead stumps and fallen timber or on low-hanging branches, using a perch-and-pounce method of hunting insect prey. It is considered a sedentary species, with relatively large home ranges (ranging from 10 hectares during the breeding season, to 30 hectares in the non-breeding season) but local seasonal movements are possible (DEC 2006ae). This species may breed any time between July and November, often rearing several broods (DEC 2006ae). Two females often cooperate in brooding (DEC 2006ae). Hooded robins appear unable to survive in remnants smaller than 100-200 hectares (NSW Scientific Committee 2001c).

a) Whether the life cycle of the species is likely to be disrupted such that a local viable population of the species is likely to be placed at risk of extinction.

The hooded robin (*Melanodryas cucullata cucullata*) was recorded within the Study Area on 11 occasions. From an analysis of known records of this species within the Study Area, the Anvil Hill Project will result in the overall loss of 60.4% of potential habitat (vegetation communities where this species was recorded) for this species.

The Study Area provides known foraging habitat for this species, as well as potential breeding habitat. Despite the presence of potential breeding habitat, no opportunistic evidence of breeding was observed during surveys of the Study Area.

This is a sedentary and territorial species, occupying relatively large home ranges that can range in size from 10 to 30 hectares. When considering the number of records of this species spread across the Study Area, it is likely that there are a number of small sub-populations of this species present. These sub-populations are likely to be represented as pairs or trios, with offspring sometimes assisting with breeding. While it is likely that there would be some interchange of genetic material between nearby sub-populations, this species is not able to readily disperse throughout fragmented landscapes.

Given that the Study Area forms part of a large fragment that is already isolated from nearby vegetation, it is likely that the hooded robins within this large fragment form a population that is already facing pressures from isolation and fragmentation. The current degree of isolation of this fragment is likely to be limiting the ability for dispersal and recruitment, thus limiting genetic inflow/outflow for this population.

The likely impact of the Anvil Hill Project will be to further isolate the sub-populations of this species within the Study Area. In particular, the sub-populations within the Proposed Disturbance Area will lose all current habitat, and this, coupled with competitive pressures for the remaining habitat within the Proposed Offset Areas, has the potential to cause local extinctions of sub-populations of this species within the Study Area. This risk of local extinctions will be further exacerbated if sub-populations within the central parts of the Study Area are lost, thus further isolating sub-populations on the outer edges of the Study Area.

The Anvil Hill Project will require the removal of a large area of vegetation containing specific habitat requirements for this species. As this is a sedentary, territorial species, it is likely that this species is not using resources from the local area, rather is confined to the vegetation within the existing remnant. The fact that a large proportion of known habitat within the Study Area will be removed suggests that there will be a significant loss of known foraging and potential nesting habitat to the hooded robins within the Study Area. This impact is likely to disrupt the life cycle of this species, such that a local viable population of this species is likely to be placed at risk of extinction.

b) In relation to the regional distribution of the habitat of the threatened species, whether a significant area of known habitat is to be modified or removed, or isolated from currently interconnecting or proximate areas.

There are a number of records of this species within the Hunter Valley. These records come from along the valley floor, as well as from the adjoining National Parks along the southern side of the valley (Wollemi and Goulburn River).

The Anvil Hill Project will require the removal of a large area of vegetation containing specific habitat requirements for this species. As the species is sedentary, territorial and lacks a high degree of mobility, it is likely that the species is entirely dependent on resources provided by the Study Area.

The Anvil Hill Project is likely to exacerbate isolation pressures already being faced by this species within the Study Area. The fact that a large proportion of known habitat within the Study Area will be removed suggests that there will be a significant loss of known foraging and potential nesting habitat to those hooded robins (*Melanodryas cucullata cucullata*) in the Study Area, and region.

c) Whether the species, or its habitat, are adequately represented in conservation reserves (or other similar protected areas) in the region.

There has been one sighting of the hooded robin (*Melanodryas cucullata cucullata*) recorded for Goulburn River National Park, and two records within Wollemi National Park (DEC 2006ae). Although present within two of the larger national parks within the region, the number of recorded sightings of the hooded robin is very low. As such, it is unlikely that the species is adequately protected within conservation reserves in the region.

d) Whether the species is at the limit of its known distribution.

The species is widespread, found across Australia, except for the driest deserts and the wetter coastal areas - northern and eastern coastal Queensland and Tasmania (DEC 2006ae). The south-eastern form of the hooded robin (*Melanodryas cucullata cucullata*) is found from Brisbane to Adelaide throughout much of inland NSW, with the exception of the north-west. This form occurs throughout NSW except for the north-west, where it intergrades with the hooded robin northern form (*Melanodryas cucullata picata*) (NSW Scientific Committee 2001c). The records of this species within the Study Area do not represent the distributional limit of this species.

27. Grey-crowned babbler – *Pomatostomus temporalis temporalis*

The grey-crowned babbler (*Pomatostomus temporalis temporalis)* is found throughout parts of northern Australia and south-eastern Australia. In NSW, the eastern sub-species occurs on the western slopes of the Great Dividing Range, and on the western plains reaching as far as Louth and Hay (DEC 2006af). It is less common on the higher tablelands (NSW Scientific Committee 2001). It also occurs in woodlands in the Hunter Valley and in several locations on the north coast of NSW (DEC 2006af). This species inhabits open Box-Gum Woodlands on the slopes, and Box-Cypress-pine and open Box Woodlands on alluvial plains. They have been recorded from open forest and woodland, acacia scrubland and adjoining open areas (Garnett & Crowley 2000). This species is highly susceptible to habitat fragmentation (Garnett & Crowley 2000), as birds are generally unable to cross large open areas (DEC 2006af). This species lives in sedentary family groups that consist of a breeding pair and young from previous breeding seasons. A group may consist of up to fifteen birds. All members of the family group remain close to each other when foraging (DEC 2006af). They feed on invertebrates, either by foraging on the trunks and branches of eucalypts and other woodland trees or on the ground, digging and probing amongst litter and tussock grasses (DEC 2006af). This species will build and maintain several conspicuous, dome-shaped stick nests, which are used as dormitories for roosting each night. Nests are usually located in shrubs or sapling eucalypts, although they may be built in the outermost leaves of low branches of large eucalypts. Nests are maintained year round, and old nests are often dismantled to build new ones (DEC 2006af). This species breeds between July and February. Young birds are fed by all members of the group (DEC 2006af). Territories range from one to fifty hectares (usually around ten hectares) and are defended all year (DEC 2006af).

a) *Whether the life cycle of the species is likely to be disrupted such that a local viable population of the species is likely to be placed at risk of extinction.*

The grey-crowned babbler (*Pomatostomus temporalis temporalis)* was recorded within the Study Area on 11 occasions. From an analysis of known records of this species within the Study Area, the Anvil Hill Project will result in the overall loss of 55.2% of potential habitat (vegetation communities where this species was recorded) for this species.

The Study Area provides known foraging habitat for this species, as well as potential breeding habitat. A number of characteristic nests were recorded during surveys, however these may have been abandoned or 'practice' nests, as are used for this species. Despite the presence of babbler nests, no further opportunistic evidence of breeding was observed during surveys of the Study Area.

This is a sedentary and territorial species, occupying home ranges that can vary in size considerably, however are generally in the order of ten hectares. When considering the number of records of this species spread across the Study Area, it is likely that there are a number of small sub-populations occurring within the Study Area. These sub-populations are likely to be represented as small family groups with a breeding pair, and some of their offspring. While it is likely that there would be some interchange of genetic material between nearby sub-populations, this species is not able to readily disperse throughout fragmented landscapes.

Given that the Study Area forms part of a large fragment that is already isolated from nearby vegetation, it is likely that the grey-crowned babblers within this large fragment form a population that is already facing pressures from isolation and fragmentation. The current degree of isolation of this fragment is likely to be limiting the ability for dispersal and recruitment, thus limiting genetic inflow/outflow for this population.

The likely impact of the Anvil Hill Project will be to further isolate the sub-populations of this species within the Study Area. In particular, the sub-populations within the Proposed Disturbance Area will lose all current habitat and this, coupled with competitive pressures for the remaining habitat within the Proposed Offset Areas, has the potential to cause local extinctions of sub-populations of this species within the Study Area. This risk of local extinctions will be further exacerbated, if sub-populations within the central parts of the Study Area are lost, thus further isolating sub-populations on the outer edges of the Study Area.

The Anvil Hill Project will require the removal of a large area of vegetation containing specific habitat requirements for this species. As this is a sedentary, territorial species with limited dispersal ability, it is likely that this species is not using resources from the local area, rather is confined to the vegetation within the existing remnant. The fact that a large proportion of known habitat within the Study Area will be removed suggests that there will be a significant loss of known foraging and potential nesting habitat to the grey-crowned babblers within the Study Area. This impact is likely to disrupt the life cycle of this species, such that a viable population of this species is likely to be placed at risk of extinction.

b) *In relation to the regional distribution of the habitat of the threatened species, whether a significant area of known habitat is to be modified or removed, or isolated from currently interconnecting or proximate areas.*

There are a large number of records of this species from the Hunter Valley. The majority of these records are from the valley floor, with some records from the fringing National Parks such as Wollemi and Goulburn River.

The Anvil Hill Project will require the removal of a large area of vegetation containing specific habitat requirements for this species. As the species is sedentary, territorial and lacks a high degree of mobility, it is likely that the species is entirely dependent on resources provided by the Study Area.

The Anvil Hill Project is likely to exacerbate isolation pressures already being faced by this species within the Study Area. The fact that a large proportion of known habitat within the Study Area will be removed suggests that there will be a significant loss of known foraging and potential nesting habitat to those grey-crowned babblers (*Pomatostomus temporalis temporalis)* in the Study Area, and region.

c) Whether the species, or its habitat, are adequately represented in conservation reserves (or other similar protected areas) in the region.

There are two records of the grey-crowned babbler (*Pomatostomus temporalis temporalis)* documented for Goulburn River National Park and four records of this species within Wollemi National Park (DEC 2006af). Although present within two of the larger national parks within the region, the number of recorded sightings of the grey-crowned babbler (*Pomatostomus temporalis temporalis)* is very low. As such, it is unlikely that the species is adequately protected within conservation reserves in the region.

d) Whether the species is at the limit of its known distribution.

In NSW, the eastern sub-species occurs on the western slopes of the Great Dividing Range, and on the western plains reaching as far as Louth and Hay (DEC 2006af). It is less common on the higher tablelands (NSW Scientific Committee 2001e). It also occurs in woodlands in the Hunter Valley and in several locations on the north coast of NSW (DEC 2006af). The records of this species within the Study Area do not represent the distributional limit for this species.

28. Olive whistler – *Pachycephala olivacea*

The olive whistler (*Pachycephala olivacea*) inhabits the wet forests on the ranges of the east coast. It has a disjunct distribution in NSW chiefly occupying the beech forests around Barrington Tops and the MacPherson Ranges in the north and wet forests from Illawarra south to Victoria (DEC 2006bj). In the south it is found inland to the Snowy Mountains and the Brindabella Range (Pizzey & Knight 2003). This species is known from coastal tea tree thickets and wet forests with thick undergrowth in southern and eastern Australia, including Tasmania, King and Flinders Islands, south and east of the Dividing Range, and in the high altitude beech forests and brushes of north-east New South Wales and south-east Queensland (Beruldsen 2003). This species mostly inhabit wet forests above about 500 metres. During the winter months they may move to lower altitudes (DEC 2006bj). The olive whistler nests once a year between September to December in a nest consisting of a shallow bowl of fine dry sticks and twigs, dry coarse grasses, pieces of bark, plant stems and some dry leaves, built into any suitable fork or thick foliage in a shrub, bush, small tree or vine and usually very well concealed (Beruldsen 2003). They forage in trees and shrubs and on the ground, feeding on berries and insects.

a) Whether the life cycle of the species is likely to be disrupted such that a local viable population of the species is likely to be placed at risk of extinction.

The olive whistler (*Pachycephala olivacea*) was not identified within the Study Area, despite extensive, seasonal surveys. It is considered that a local viable population of this species is not likely to be present within the Study Area.

The Anvil Hill Project is unlikely to disrupt a local viable population of the species, such that the species is likely to be placed at risk of extinction.

b) In relation to the regional distribution of the habitat of the threatened species, whether a significant area of known habitat is to be modified or removed, or isolated from currently interconnecting or proximate areas.

The olive whistler (*Pachycephala olivacea*) was not identified within the Study Area, despite extensive, seasonal surveys. The Study Area does not contain a significant area of known habitat for this species, and it is considered unlikely that this species is present within the Study Area.

A significant area of known habitat for this species will not be modified or removed, or isolated from currently interconnecting or proximate areas as a result of the Anvil Hill Project.

There are no records of this species from the floor of the Hunter Valley. This species is mainly recorded from nearby heavily-vegetated areas such as Barrington Tops National Park, Watagan State Forest and Ben Halls Gap National Park. There are no regional records of this species outside of these areas.

c) Whether the species, or its habitat, are adequately represented in conservation reserves (or other similar protected areas) in the region.

The olive whistler (*Pachycephala olivacea*) has been recorded within Mount Royal National Park, with three records being documented (DEC 2006bj). Given that this species occurs in high altitude mountain areas, which are well-reserved, it is likely that it is adequately represented in conservation reserves in the region.

d) Whether the species is at the limit of its known distribution.

The olive whistler (*Pachycephala olivacea*) inhabits the wet forests on the ranges of the east coast. It has a disjunct distribution in NSW chiefly occupying the beech forests around Barrington Tops and the MacPherson Ranges in the north and wet forests from Illawarra south to Victoria (DEC 2006bj). In the south it is found inland to the Snowy Mountains and the Brindabella Range (Pizzey & Knight 2003). This species is known from coastal tea tree thickets and wet forests with thick undergrowth in southern and eastern Australia, including Tasmania, King and Flinders Islands, south and east of the Dividing Range, and in the high altitude beech forests and brushes of north-east New South Wales and south-east Queensland (Beruldsen 2003). This species mostly inhabit wet forests above about 500 metres. During the winter months they may move to lower altitudes (DEC 2006bj). A record of this species from the Study Area would represent the first record of this species from the floor of the Hunter Valley, as well as one of the few records of this species from the region, in general. Such a record would represent the western-most record of this species from the Hunter Valley, however not for New South Wales.

29. Diamond firetail – *Stagonopleura guttata*

The diamond firetail (*Stagonopleura guttata*) is widely distributed in NSW, with a concentration of records from the Northern, Central and Southern Tablelands, the Northern, Central and South Western Slopes and the North West Plains and Riverina. It is not commonly found in coastal districts, though there are records from near Sydney, the Hunter Valley and the Bega Valley. This species has a scattered distribution over the rest of NSW. Also found in the Australian Capital Territory, Queensland, Victoria and South Australia (DEC 2006ah). Habitat includes a range of eucalypt-dominated communities with a grassy understorey, including woodland, forest and mallee (Garnett & Crowley 2000). It appears that populations are unable to persist in areas where there are no vegetated remnants larger than 200 hectares (NSW Scientific Committee 2001f). This species feeds exclusively on the ground, on ripe and partly-ripe grass and herb seeds and green leaves, and on insects (especially in the breeding season). Diamond firetails are usually encountered in flocks of between five to 40 birds, occasionally more. Groups separate into small colonies to breed, between August and January. Birds roost in dense shrubs or in smaller nests built especially for roosting. This species appears to be sedentary, though some populations move locally, especially those from southern areas (DEC 2006ah).

a) Whether the life cycle of the species is likely to be disrupted such that a local viable population of the species is likely to be placed at risk of extinction.

The diamond firetail (*Stagonopleura guttata*) was recorded within the Study Area on 10 occasions. From an analysis of known records of this species within the Study Area, the Anvil Hill Project will result in the overall loss of 59.1% of potential habitat (vegetation communities where this species was recorded) for this species.

The Study Area provides known foraging habitat for this species, as well as potential breeding habitat. Despite the presence of potential breeding habitat, no opportunistic evidence of breeding was observed during surveys of the Study Area.

This is a sedentary species. When considering the number of records of this species spread across the Study Area, it is likely that there are small sub-populations of this species occurring within the Study Area. These sub-populations are likely to be represented as small breeding flocks, or larger flocks during the non-breeding season. While it is likely that there would be some interchange of genetic material between nearby sub-populations, this species is not able to readily disperse throughout fragmented landscapes.

Given that the Study Area forms part of a large fragment that is already isolated from nearby vegetation, it is likely that the diamond firetails within this large fragment form a population that is already facing pressures from isolation and fragmentation. The current degree of isolation of this fragment is likely to be limiting the ability for dispersal and recruitment, thus limiting genetic inflow/outflow for this population.

The likely impact of the Anvil Hill Project will be to further isolate the sub-populations of this species within the Study Area. In particular, the sub-populations within the Proposed Disturbance Area will lose all current habitat, and this, coupled with competitive pressures for the remaining habitat within the Proposed Offset Areas, has the potential to cause local extinctions of sub-populations of this species within the Study Area. This risk of local extinctions will be further exacerbated, if sub-populations within the central parts of the Study Area are lost, thus further isolating sub-populations on the outer edges of the Study Area.

The Anvil Hill Project will require the removal of a large area of vegetation containing specific habitat requirements for this species. As this is a sedentary species with limited dispersal ability, it is likely that this species is not using resources from the local area, rather is confined to the vegetation within the existing remnant. The fact that a large proportion of known habitat within the Study Area will be removed suggests that there will be a significant loss of known foraging and potential nesting habitat to the diamond firetails within the Study Area. This impact is likely to disrupt the life cycle of this species, such that a local viable population of this species is likely to be placed at risk of extinction.

b) In relation to the regional distribution of the habitat of the threatened species, whether a significant area of known habitat is to be modified or removed, or isolated from currently interconnecting or proximate areas.

This species has been recorded from a number of sites within the Hunter Valley. A number of these records are from Wollemi and Goulburn River National Parks, however there are also a number of records from the Muswellbrook area.

The Anvil Hill Project will require the removal of a large area of vegetation containing specific habitat requirements for this species. As the species is sedentary and lacks a high degree of mobility, it is likely that the species is entirely dependent on resources provided by the Study Area.

The Anvil Hill Project is likely to exacerbate isolation pressures already being faced by this species within the Study Area. The fact that a large proportion of known habitat within the Study Area will be removed suggests that there will be a significant loss of known foraging and potential nesting habitat to those diamond firetails (*Stagonopleura guttata*) in the Study Area, and region.

c) Whether the species, or its habitat, are adequately represented in conservation reserves (or other similar protected areas) in the region.

Three records of the diamond firetail (*Stagonopleura guttata*) have been documented within Goulburn River National Park, and 12 records are known for Wollemi National Park. Although present within two of the larger national parks within the region, the number of recorded sightings of the diamond firetail is very low. As such, it is unlikely that this species is adequately protected within conservation reserves in the region.

d) Whether the species is at the limit of its known distribution.

The diamond firetail (*Stagonopleura guttata*) is widely distributed in NSW, with a concentration of records from the Northern, Central and Southern Tablelands, the Northern, Central and South Western Slopes and the North West Plains and Riverina. Not commonly found in coastal districts, though there are records from near Sydney, the Hunter Valley and the Bega Valley. This species has a scattered distribution over the rest of NSW. Also found in the Australian Capital Territory, Queensland, Victoria and South Australia (DEC 2006ah). The records of this species within the Study Area are not at the limit of the species' distribution.

30. Spotted-tailed quoll - *Dasyurus maculatus maculatus*

In NSW, the spotted-tailed quoll (*Dasyurus maculatus*) occurs on both sides of the Great Dividing Range, with highest densities occurring in the north east of the state. It occurs from the coast to the snowline and inland to the Murray River (Edgar & Belcher 2002). The southern subspecies (*Dasyurus maculatus maculatus*) is found from south-east Queensland, through NSW and Victoria to Tasmania. Only in Tasmania is this species still considered common (DEC 2006bk). Habitat for this species is highly varied, ranging from sclerophyll open forest, woodlands, coastal heathlands, rainforests and inland riparian forest, from the sub-alpine zone to the coastline. Records exist from open country, grazing lands and rocky outcrops (NSW NPWS 1999i). Individual animals use hollow-bearing trees, fallen logs, small caves, rock crevices, boulder fields and rocky-cliff faces as den sites (DEC 2006bk). Females occupy home ranges up to about 750 hectares and males up to 3500 hectares, and usually traverse their ranges along densely vegetated creeklines (DEC 2006i). These home ranges are often defined by a number of 'latrines' (Edgar & Belcher 2002) which are often in exposed areas such as rocky outcrops. This species is mostly nocturnal, although it will hunt during the day. When hunting, it spends most of the time on the ground, although it is also an excellent climber and may raid possum and glider dens and prey on roosting birds (DEC

2006bk). Breeding occurs generally between April and July (Edgar & Belcher 2002). This species feeds on a variety of species, ranging in size from small wallabies to insects and carrion (Edgar & Belcher 2002).

a) *Whether the life cycle of the species is likely to be disrupted such that a local viable population of the species is likely to be placed at risk of extinction.*

The spotted-tailed quoll (*Dasyurus maculatus maculatus*) was not recorded within the study area, despite extensive seasonal surveys. During fauna surveys in 2004, a call was heard that was similar to the 'circular saw' call known to be made by this species, however the call was too short and too distant to be able to verify. Extensive surveys failed to locate any other evidence of the species, such as latrine sites. The spotted-tailed quoll is an elusive, trap shy species which is difficult to detect. It occurs at low densities characterized by large home ranges, a further hindrance to identifying the species in the field. Despite the lack of confirmed records, it is considered possible that this species may occur within the Study Area. This is based on the availability of potentially suitable habitat and the small number of historic records of this species with a twenty kilometer radius of the Study Area.

It is likely that the Study Area forms habitat for a population of spotted-tailed quolls that extends to the west, north-west and south-west into the remote escarpment country of Manobalai Crown Land. It is also likely that the Study Area forms marginal habitat for a population with a core area in the remote escarpment country to the west, north-west and south-west. There is potential foraging habitat for this species across the Study Area, as well as potential breeding and denning habitat in the form of hollow logs, hollow-bearing trees, and rocky escarpment areas.

While the Project will result in the loss of a large amount of likely habitat for this species, direct habitat loss is not likely to increase the potential for local extinction of this species. This is due to the highly mobile nature of this species, the presence of potential habitat in nearby or adjoining vegetated areas, and the retention of large areas of potential habitat within the Proposed Offset Areas.

The failure to record the spotted-tailed quoll and the likelihood the Study Area forms marginal habitat suggests that the life cycle of the spotted-tailed quoll is unlikely to be disrupted by the Anvil Hill Project such that a local viable population of the species is likely to be placed at risk of extinction.

b) *In relation to the regional distribution of the habitat of the threatened species, whether a significant area of known habitat is to be modified or removed, or isolated from currently interconnecting or proximate areas.*

There are a large number of records of this species from the Hunter Valley, both from the valley floor, and the fringing Wollemi and Barrington Tops National Parks. The majority of records are from coastal, or near-coastal areas, with records diminishing towards the west.

The Anvil Hill Project will require both the removal and conservation of large areas of vegetation containing potential habitat for the spotted-tailed quoll. It is likely that the Study Area provides marginal habitat for the species and that a core population area does not occur within the Study Area. It is likely that a core population area occurs in the Manobalai Crown Land area to the west of the Study Area. No significant area of known habitat was identified during field survey for the Project, and a significant area of known habitat will not be modified or removed, or isolated from currently interconnecting or proximate areas.

c) Whether the species, or its habitat, are adequately represented in conservation reserves (or other similar protected areas) in the region.

There are nine records of the spotted-tailed quoll (*Dasyurus maculatus maculatus*) within Mount Royal National Park, while there are four records for Wollemi National Park (DEC 2006bk). Although present within two of the larger national parks within the region, the number of recorded sightings of the spotted-tailed quoll (*Dasyurus maculatus maculatus*) is very low. As such, it is unlikely that this species is adequately protected within conservation reserves in the region.

d) Whether the species is at the limit of its known distribution.

In NSW, the spotted-tailed quoll (*Dasyurus maculatus maculatus*) occurs on both sides of the Great Dividing Range, with highest densities occurring in the north east of the state. It occurs from the coast to the snowline and inland to the Murray River (Edgar & Belcher 2002). The southern subspecies (*Dasyurus maculatus maculatus*) is found from south-east Queensland, through NSW and Victoria to Tasmania. Only in Tasmania is this species still considered common (DEC 2006bk). A record of this species within the Study Area would not be at the distributional limit for the species.

31. Brush-tailed phascogale – *Phascogale tapoatafa tapoatafa*

The brush-tailed phascogale (*Phascogale tapoatafa tapoatafa*) has a patchy distribution around the coast of Australia. In NSW it is more frequently found in forest on the Great Dividing Range in the north-east and south-east of the State. There are also a few records from central NSW (DEC 2006bl). This southern subspecies occurs from Rockhampton in Queensland to the Mt Lofty Ranges in South Australia (NSW NPWS 1999f). It prefers dry sclerophyll open forest with sparse groundcover of herbs, grasses, scleromorphic shrubs or leaf litter (DEC 2006bl). They have also been recorded from heathland, swamps, rainforest and wet sclerophyll forest. They are agile climbers, foraging for invertebrates and arthropods (as well as nectar) generally on rough-barked trees of 25 cm DBH or higher, where available (DEC 2006bl). Nests are made in hollow tree limbs, rotten stumps and sometimes birds nests, and a number of these are used in rotation (Soderquist 2002). Female home ranges span 20-70 hectares, while males can occupy twice the area (Soderquist 2002). Dispersal occurs in mid-summer with young males moving many kilometres while females settle in nearby vacant territories or share the maternal home range (Soderquist 2002). Breeding occurs between May and June. Males die soon after the mating season whereas females can live for up to three years but generally only produce one litter (DEC 2006bl).

a) Whether the life cycle of the species is likely to be disrupted such that a local viable population of the species is likely to be placed at risk of extinction.

The brush-tailed phascogale (*Phascogale tapoatafa tapoatafa*) was not identified within the Study Area, despite extensive, seasonal surveys. It is considered that a local viable population of this species is not likely to be present within the Study Area.

The Anvil Hill Project is unlikely to disrupt a local viable population of the species, such that the species is likely to be placed at risk of extinction.

b) In relation to the regional distribution of the habitat of the threatened species, whether a significant area of known habitat is to be modified or removed, or isolated from currently interconnecting or proximate areas.

The brush-tailed phascogale (*Phascogale tapoatafa tapoatafa*) was not identified within the Study Area, despite extensive, seasonal surveys. The Study Area does not contain a significant area of known habitat for this species, and it is considered unlikely that this species is present within the Study Area.

A significant area of known habitat for this species will not be modified or removed, or isolated from currently interconnecting or proximate areas as a result of the Anvil Hill Project.

Records of this species from the Hunter Valley are mainly from coastal or near-coastal areas such as the Nelson Bay – Clarencetown area. There is a small cluster of records of this species in the Singleton area, however there are no records further west along the valley.

c) Whether the species, or its habitat, are adequately represented in conservation reserves (or other similar protected areas) in the region.

There is one record of the brush-tailed phascogale (*Phascogale tapoatafa tapoatafa*) documented for Mount Royal National Park (DEC 2006bl). Given that this species has only been recorded within one conservation reserve within the region, it is unlikely that this species is adequately protected.

d) Whether the species is at the limit of its known distribution.

The brush-tailed phascogale (*Phascogale tapoatafa tapoatafa*) has a patchy distribution around the coast of Australia. In NSW it is more frequently found in forest on the Great Dividing Range in the north-east and south-east of the State. There are also a few records from central NSW (DEC 2006bl). This southern subspecies occurs from Rockhampton in Queensland to the Mt Lofty Ranges in South Australia (NSW NPWS 1999f). A record of this species from the Study Area would represent the western-most record of this species from the Hunter Valley,

32. Koala – *Phascolarctos cinereus*

The koala (*Phascolarctos cinereus*) has a fragmented distribution throughout eastern Australia, with the majority of records from NSW occurring on the central and north coasts, as well as some areas further west (NSW NPWS 1999g). It is known to occur along inland rivers on the western side of the Great Dividing Range (NSW NPWS 1999g). This species inhabits eucalypt forest and woodland, with suitability influenced by tree species and age, soil fertility, climate, rainfall and fragmentation patterns (NSW NPWS 1999g). This species will feed on the foliage of more than 70 eucalypt species and 30 non-eucalypt species, but in any one area will select preferred browse species (DEC 2006ai). Home ranges vary considerably according to habitat quality, with an average of 10 to 15 hectares in the Pilliga State Forest to an average of 80 to 90 hectares in the Port Stephens area (NSW NPWS 1999g). Young are generally produced in summer, remaining with the mother for up to three years (NSW NPWS 1999g). Koalas (*Phascolarctos cinereus*) spend most of their time in trees, but will descend and traverse open ground to move between trees (DEC 2006ai).

a) Whether the life cycle of the species is likely to be disrupted such that a local viable population of the species is likely to be placed at risk of extinction.

Detailed SEPP 44 assessments have been completed across the Study Area, and these results are provided in **Figure 5.2** of the main document. This assessment identified six sites of potential koala habitat out of a total of 158 survey sites. Of these, only one potential koala habitat site occurred within the Proposed Disturbance Area. Detailed spotlighting, call playback and diurnal searches failed to identify the koala from the Study Area, however, a small number of koala scats were recorded from a single tree in the Proposed Offset Areas. No koalas (*Phascolarctos cinereus*) or koala scats were identified in any part of the Proposed Disturbance Area despite a significant level of survey effort.

The failure to find koalas or more than one site containing koala scats suggests that Proposed Offset Areas is of very marginal habitat quality for the koala. This is most likely to only be used by dispersing individuals or sub-dominant animals at very low density. Therefore the Proposed Offset Areas does not provide core koala habitat.

While evidence of the koala was recorded during surveys, it is unlikely that the Study Area provides habitat for a resident population of this species. Rather, it is likely that small numbers of this species would use the habitat within the Study Area periodically, as part of a larger range.

From an analysis of known records of this species within the Study Area, the Anvil Hill Project will result in the overall loss of 63.6% of potential habitat (vegetation communities where this species was recorded) for this species.

The Anvil Hill Project will require the removal of a large area of vegetation containing specific habitat requirements for this species. As the Study Area provides only very marginal habitat quality for the koala, it is very unlikely that the species is entirely dependant on resources provided by the Study Area. The impact from the Anvil Hill Project is unlikely to cause an impact that is likely to disrupt the life cycle of this species, such that a local viable population of this species is likely to be placed at risk of extinction.

b) In relation to the regional distribution of the habitat of the threatened species, whether a significant area of known habitat is to be modified or removed, or isolated from currently interconnecting or proximate areas.

There are a large number of records of this species within the Hunter Valley. Particular concentrations of records exist in the Port Stephens/Nelson Bay/Raymond Terrace/Medowie areas, however records extend all the way west along the valley. Most records of this species in the region are from large areas of remnant vegetation or nearby conservation reserves such as Barrington Tops, Wollemi, Yengo and Goulburn River National Parks. Other records come from Warrambungle and Coolah Tops National Parks. In relation to the Study Area, records of this species come from Manobalai Nature Reserve and near Denman.

The Anvil Hill Project will require the removal of a large area of vegetation containing specific habitat requirements for this species. As the species is likely to be using such resources from a variety of locations within the local area, it is not likely that the species is entirely dependent on resources provided by the Study Area. Due to the expected low-level usage of the Study Area by this species, it is not considered that a significant area of known habitat for this species will become modified or isolated from currently interconnecting or proximate areas.

c) Whether the species, or its habitat, are adequately represented in conservation reserves (or other similar protected areas) in the region.

There are four conservation reserves in the region in which the koala has been recorded. These are Manobalai Nature Reserve (two records) (DEC 2006ai), Mount Royal National Park (six records) (DEC 2006ai), Wollemi National Park (28 records) (NPWS Wildlife Atlas Database) and Goulburn River National Park (one record) (DEC 2006ai).

Although there are several records of the koala (*Phascolarctos cinereus*) within conservation reserves in the region, available habitat for this species has drastically declined due to high rates of land clearance and degradation through mining and agricultural activities. Despite this, it is unlikely that this species is adequately protected within conservation reserves in the region.

d) Whether the species is at the limit of its known distribution.

The koala (*Phascolarctos cinereus*) has a fragmented distribution throughout eastern Australia, with the majority of records from NSW occurring on the central and north coasts, as well as some areas further west (NSW NPWS 1999g). It is known to occur along inland rivers on the western side of the Great Dividing Range (NSW NPWS 1999g). The record of this species from the Study Area does not represent the limit of distribution for the species.

33. Eastern pygmy possum – *Cercartetus nanus*

The eastern pygmy-possum (*Cercartetus nanus*) occurs in the south-eastern corner of mainland Australia and in Tasmania. In NSW it extents from the coast inland as far as the Pillaga, Dubbo, Parkes and Wagga Wagga on the western slopes (DEC 2006bm). This species is found in a variety of habitat types, ranging from rainforest, through sclerophyll forest to tree heaths (Turner & Ward 2002). Here, they feed primarily on nectar and pollen from banksias, eucalypts and bottlebrushes. Insects, seeds and fruits are also eaten (Turner & Ward 2002). Male home ranges are estimated at 0.68 hectares, while females' ranges are smaller at 0.35 hectares (Turner & Ward 2002). It frequently spends time in torpor especially in winter, with body curled, ears folded and internal temperature close to the surroundings (DEC 2006bm). This species is highly elusive and notoriously difficult to detect during survey. Breeding occurs any time the year, providing there is adequate food supply (Turner & Ward 2002), however most births occur between late spring and early autumn (DEC 2006bm). Nest-building appears to be restricted to breeding females; tree hollows are favoured but spherical nests have been found under the bark of eucalypts and in shredded bark in tree forks (DEC 2006bm). This species appears to be mainly solitary, each individual using several nests. They are agile climbers, but can be caught on the ground in traps, pitfalls or postholes. They are generally nocturnal.

a) Whether the life cycle of the species is likely to be disrupted such that a local viable population of the species is likely to be placed at risk of extinction.

The eastern pygmy-possum (*Cercartetus nanus*) was not identified within the Study Area, despite extensive, seasonal surveys. It is considered that a local viable population of this species is not likely to be present within the Study Area.

The Anvil Hill Project is unlikely to disrupt a local viable population of the species, such that the species is likely to be placed at risk of extinction.

b) In relation to the regional distribution of the habitat of the threatened species, whether a significant area of known habitat is to be modified or removed, or isolated from currently interconnecting or proximate areas.

The eastern pygmy-possum (*Cercartetus nanus*) was not identified within the Study Area, despite extensive, seasonal surveys. The Study Area does not contain a significant area of known habitat for this species, and it is considered unlikely that this species is present within the Study Area.

A significant area of known habitat for this species will not be modified or removed, or isolated from currently interconnecting or proximate areas as a result of the Anvil Hill Project.

There are very few records of this species from the Hunter Valley. Two records occur from Barrington Tops National Park, and the remaining records are from Wollemi National Park. There are no records of this species from the floor of the Hunter Valley.

c) Whether the species, or its habitat, are adequately represented in conservation reserves (or other similar protected areas) in the region.

There have been no sightings of the eastern pygmy possum (*Cercartetus nanus*) recorded within any of the nine conservation reserves identified within the region surrounding the Study Area. As such, it is unlikely that this species is adequately represented in conservation reserves within the region.

d) Whether the species is at the limit of its known distribution.

The eastern pygmy-possum (*Cercartetus nanus*) occurs in the south-eastern corner of mainland Australia and in Tasmania. In NSW it extents from the coast inland as far as the Pillaga, Dubbo, Parkes and Wagga Wagga on the western slopes (DEC 2006bm). A record of this species from the Study Area would represent the only record of this species from the floor of the Hunter Valley, as well as one of the few known from private land in the area.

34. Squirrel glider – *Petaurus norfolcensis*

The squirrel glider (*Petaurus norfolcensis*) is widely though sparsely distributed in eastern Australia, from northern Queensland to western Victoria (DEC 2006aj). This species generally inhabits dry sclerophyll forest and woodland, also being recorded from coastal and wet forests in the northern parts of NSW and Queensland (Suckling 2002). Preferred foraging habitat contains a regenerating understorey of eucalypts, wattles and flowering shrubs, allowing them to feed on arboreal invertebrates, eucalypt nectar, pollen and sap, and the seeds and gum of acacia species (NSW Scientific Committee 2000h). Winter flowering species such as red ironbark (*Eucalyptus fibrosa*), spotted gum (*Corymbia maculata*) and coast banksia (*Banksia integrifolia*) are particularly important when other food sources are limited. Family groups den in tree hollows, particularly in smooth-barked species (NSW NPWS 1999h). Home ranges vary between 0.65 and 8.55 hectares (NSW NPWS 1999h). This species nests in bowl-shaped, leaf lined nests in tree hollows. They live in family groups of a single adult male one or more adult females and offspring, and require abundant tree hollows for refuge and nest sites (DEC 2006aj). Births occur throughout the year, and can vary according to food availability (NSW NPWS 1999h). Diet varies seasonally and consists of *Acacia* gum, eucalypt sap, nectar, honeydew and manna, with invertebrates and pollen providing protein.

a) Whether the life cycle of the species is likely to be disrupted such that a local viable population of the species is likely to be placed at risk of extinction.

The squirrel glider (*Petaurus norfolcensis*) was recorded within the Study Area on six occasions. From an analysis of known records of this species within the Study Area, the Anvil Hill Project will result in the overall loss of 61.6% of potential habitat (vegetation communities where this species was recorded) for this species.

The Study Area provides known foraging habitat for this species, as well as potential denning and breeding habitat in the form of medium sized hollows. These are present across the Study Area, with similar densities recorded across the Proposed Disturbance Area and Proposed Offset Areas. Despite the presence of hollows suitable for this species, no evidence of breeding was observed during surveys of the Study Area.

This is a relatively sedentary species. When considering the number of records of this species spread across the Study Area, it is likely that there are a small number of sub-populations of this species occurring within the Study Area. These sub-populations are likely to be represented as small family groups. While it is likely that there would be some interchange of genetic material between nearby sub-populations, this species is not able to readily disperse throughout fragmented landscapes.

Given that the Study Area forms part of a large fragment that is already isolated from nearby vegetation, it is likely that the squirrel gliders within this large fragment form a population that is already facing pressures from isolation and fragmentation. The current degree of isolation of this fragment is likely to be limiting the ability for dispersal and recruitment, thus limiting genetic inflow/outflow for this population.

The likely impact of the Anvil Hill Project will be to further isolate the sub-populations of this species within the Study Area. In particular, the sub-populations within the Proposed Disturbance Area will lose all current habitat and this, coupled with competitive pressures for the remaining habitat within the Proposed Offset Areas, has the potential to cause local extinctions of sub-populations of this species within the Study Area. This risk of local extinctions will be further exacerbated, if sub-populations within the central parts of the Study Area are lost, thus further isolating sub-populations on the outer edges of the Study Area.

The Anvil Hill Project will require the removal of a large area of vegetation containing specific habitat requirements for this species. As this is a sedentary species with limited dispersal ability, it is likely that it is not using resources from the local area, rather is confined to the vegetation within the existing remnant. The fact that a large proportion of known habitat within the Study Area will be removed suggests that there will be a significant loss of known foraging and potential nesting habitat to the squirrel gliders within the Study Area. This impact is likely to disrupt the life cycle of this species, such that a local viable population of this species is likely to be placed at risk of extinction.

b) In relation to the regional distribution of the habitat of the threatened species, whether a significant area of known habitat is to be modified or removed, or isolated from currently interconnecting or proximate areas.

There are a large number of records of this species from the Hunter Valley, however most of these records are from coastal or near-coastal areas. Records of this species from the floor of the Upper Hunter region are not common. There are a number of records of this species from fringing conservation reserves, particularly from Yengo and Wollemi National Parks.

The Anvil Hill Project will require the removal of a large area of vegetation containing specific habitat requirements for this species. As the species is sedentary and lacks a high degree of mobility, it is likely that the species is entirely dependent on resources provided by the Study Area.

The Anvil Hill Project is likely to greatly exacerbate isolation pressures already being faced by this species within the Study Area. The fact that a large proportion of known habitat within the Study Area will be removed suggests that there will be a significant loss of known foraging and potential denning and breeding habitat to those squirrel gliders (*Petaurus norfolcensis*) in the Study Area, and region.

c) Whether the species, or its habitat, are adequately represented in conservation reserves (or other similar protected areas) in the region.

There is one record of the squirrel glider (*Petaurus norfolcensis*) in both Goulburn River National Park and Mount Royal National Park (DEC 2006aj), while there are 14 records for Wollemi National Park (NPWS Wildlife Atlas Database 2006).

Although present within three of the larger national parks within the region, the number of recorded sightings of the squirrel glider is very low. As such, it is unlikely that this species is adequately protected within conservation reserves in the region.

d) Whether the species is at the limit of its known distribution.

The squirrel glider (*Petaurus norfolcensis*) is widely though sparsely distributed in eastern Australia, from northern Queensland to western Victoria (DEC 2006aj). This species generally inhabits dry sclerophyll forest and woodland, also being recorded from coastal and wet forests in the northern parts of NSW and Queensland (Suckling 2002). The records of this species from the Study Area represent one of the few records of this species from the Upper Hunter region, however do not represent a distributional limit for the species.

35. Brush-tailed rock-wallaby – *Petrogale penicillata*

Historically, the brush-tailed rock-wallaby (*Petrogale penicillata*) occurred from the Grampians in western Victoria to Nanago in south-eastern Queensland, roughly following the line of the Great Dividing Range (DEC 2005a). The number of brush-tailed rock-wallabies has declined and the species' range has reduced and fragmented. The greatest declines have occurred in Victoria and in western and southern New South Wales, resulting in small isolated populations throughout the species' former range, particularly in the south (DEC 2005a). In NSW they occur from the Queensland border in the north to the Shoalhaven in the south, with the population in the Warrumbungle Ranges being the western limit (DEC 2006ak). This species occupies rocky escarpments, outcrops and cliffs showing a preference for complex structures with fissures, caves and ledges facing north (DEC 2006ak). The habitat utilized by the brush-tailed rock-wallaby has been classified into three categories: (i) loose piles of large boulders containing a maze of subterranean holes and passage ways; (ii) cliffs (usually over 15 metres high) with many mid-level ledges and with some caves and/or ledges covered by overhangs; and (iii) isolated rock stacks, usually sheer-sided and often girded with fallen boulders (Short 1982). They forage mostly at night and feed predominantly on a wide variety of grasses, herbs and shrubs (DEC 2005a). They browse on vegetation in and adjacent to rocky areas eating grasses and forbs as well as the foliage and fruits of shrubs and trees (DEC 2006ak). Rock-wallabies shelter or bask during the day in rock crevices, caves and overhangs and are most active at night. They are highly territorial and have strong site fidelity with an average home range size of about 15 hectares (DEC 2006ak). They live in family groups of 2 – 5 adults and usually one or two juvenile and sub-adult individuals. Breeding is likely to be continuous, at least in the southern populations, with no apparent seasonal trends in births (DEC 2006ak).

a) Whether the life cycle of the species is likely to be disrupted such that a local viable population of the species is likely to be placed at risk of extinction.

The record of the brush-tailed rock-wallaby (*Petrogale penicillata*) comes from the positive identification of a number of scats found in caves and overhangs on the Limb of Addy Hill escarpment, within the in the Proposed Offset Areas. Despite the large amount of seasonal field survey (including targeted field survey for this species), no brush-tailed rock-wallabies were observed. No further indication of the presence of this species was recorded from the Study Area. There is 125.9 hectares of rugged outcrop and escarpment habitat present in the Study Area which, if this species are still present, could provide suitable refuge and foraging habitat. It is also likely that an unknown but potentially substantial area of woodland surrounding the rocky outcrops could provide foraging habitat for the species. While some proportion of the latter habitat would be removed by the project, none of the outcrop and escarpment areas will be removed.

Brush-tailed rock-wallaby scats collected from caves and similar areas can only be grouped into two possible age categories of either fresh scats or old scats. In dry environments such as dusty caves and overhangs, scats would dry out rapidly and become 'old scats' in a matter of days. Only old scats were identified which may have been anywhere from several days to several years in age. As a result, it was not possible to determine if they were deposited recently or some time ago.

Whether extant or not, the records of this species within the Study Area are likely to be related to known populations of this species within nearby Yengo, Wollemi and Goulburn River National Parks. These populations all fall within what is known as the Central Evolutionary Significant Unit (ESU) of this species (DEC 2005 Recovery Plan). Populations occurring within this ESU have been identified as being genetically distinct from those occurring within the Northern ESU and Southern ESU, respectively. Within the Central ESU, there is one listed endangered population, a number of populations facing marked declines, and a growing number of extinct populations (NSW Scientific Committee 2003a).

Of particular concern for this species is the increased isolation of the remaining small populations, leading to severe local declines and eventual extinctions (DEC 2005a). While it is not possible to confirm this, it is highly likely that a small population of this species was once resident on the Limb of Addy Hill area, however this population has become extinct due to the actions of a number of threatening processes operating on the population. Such process would have included gradual habitat loss, genetic isolation, reduced dispersal/recruitment ability, predation and competition with introduced herbivores.

Due to the lack of records of live animals (despite a large survey effort, including targeted surveys for this species), it is considered unlikely that an extant population of this species is present within the Study Area. The Anvil Hill Project will require the removal of a large area of vegetation containing habitat requirements for this species. However, there will be no loss of rocky escarpment areas as a result of the Anvil Hill Project. This will maintain all existing refuge areas for this species within the Study Area. As such, the Anvil Hill Project is considered unlikely to disrupt the life cycle of this species, such that a local viable population of this species is likely to be placed at risk of extinction.

b) In relation to the regional distribution of the habitat of the threatened species, whether a significant area of known habitat is to be modified or removed, or isolated from currently interconnecting or proximate areas.

There are a number of records of this species from the region, however very few are from the valley floor. The majority of records occur in clusters along the northern edges of Wollemi, Yengo and Goulburn River National Parks. Those few records that do occur outside of these large reserves are mostly from areas of remnant vegetation that have been protected in nature reserves, or the like.

The Anvil Hill Project will require the removal of a large area of vegetation containing specific habitat requirements for this species. As the species is sedentary and lacks a high degree of mobility, it is likely that, if present, the species would be entirely dependent on resources provided by the Study Area.

However, as it is considered unlikely that an extant population of this species is present within the Study Area, it is not likely that a significant area of known habitat will be modified, removed or isolated as a result of the Anvil Hill Project.

c) Whether the species, or its habitat, are adequately represented in conservation reserves (or other similar protected areas) in the region.

There are four conservation reserves within the region in which the brush-tailed rock wallaby (*Petrogale penicillata*) has been recorded. This includes four records from Goulburn River National Park, two records from Manobalai Nature Reserve, one record from Wingen Maid Nature Reserve and 37 records from Wollemi National Park (DEC 2006ak).

Although there are several records of the brush-tailed rock-wallaby within conservation reserves in the region, available habitat for this species has declined due to high rates of land clearance and degradation through mining and agricultural activities. Despite this, it is likely that this species is adequately protected within conservation reserves in the region.

d) Whether the species is at the limit of its known distribution.

In NSW they occur from the Queensland border in the north to the Shoalhaven in the south, with the population in the Warrumbungle Ranges being the western limit (DEC 2006ak). The records of this species from the Study Area are not at the limit of distribution of this species, however they do represent some of the few records of this species outside of the major conservation reserves of the region.

36. Grey-headed flying-fox – *Pteropus poliocephalus*

This species has generally been recorded within 200 kilometres of the eastern coast, from Bundaberg in Queensland, through NSW and south to eastern Victoria. Regular movements are made over the Great Dividing Range to the western slopes of NSW and Queensland. This species is known to occur in subtropical and temperate rainforests, tall sclerophyll forests and woodlands, heaths and swamps as well as urban gardens and cultivated fruit crops (DEC 2006bn). Grey-headed flying-foxes (*Pteropus poliocephalus*) feed on a variety of flowering and fruiting plants, including native figs and palms, blossoms from eucalypts, angophoras, tea-trees and banksias (Tidemann 2002). This species will travel up to 50 kilometres a night to forage (DEC 2006bn). It plays an important role in seed dispersal (NSW NPWS 2001h). Camp sites are usually formed in gullies, usually in vegetation with a dense canopy and not far from water (Tidemann 2002). Individuals generally exhibit a high fidelity to traditional camps and return annually to give birth and rear offspring (NSW Scientific Committee 2001h). Single camps may have tens of thousands of animals. Most births occur in September or October (Churchill 1998).

a) Whether the life cycle of the species is likely to be disrupted such that a local viable population of the species is likely to be placed at risk of extinction.

The grey-headed flying-fox (*Pteropus poliocephalus*) was not recorded within the Study Area, despite extensive, seasonal surveys. The Study Area provides potential foraging habitat for this species, however does not provide suitable roosting habitat in the form of identified camp sites. The Study Area does not provide habitat typical for camp sites. Due to the large amounts of seasonal survey completed, it is likely that this species would have been observed if currently present in the Study Area. This highly mobile species is able to travel large distances daily, and likely to make use of habitat within a number of vegetated areas within the region. It is considered that there is not a local viable population of this species centred within the Study Area.

It is considered unlikely that the Anvil Hill Project will result in the disruption of a local viable population of this species, such that it will be placed at risk of extinction.

b) In relation to the regional distribution of the habitat of the threatened species, whether a significant area of known habitat is to be modified or removed, or isolated from currently interconnecting or proximate areas.

The majority of the records for this species within the Hunter Valley are from coastal or near-coastal regions. There is only one record of this species to the west of Singleton, this being from near Coolah. The distribution of this species shows a strong affinity to areas east of Singleton, and it is possible that the rare records to the west of this area may be a result of this species following large rivers inland.

The large size of the Study Area, as well as the habitat types provided within it, suggest that if this species was recorded during surveys, this would be an important habitat area for this species within the region.

The Anvil Hill Project is likely to increase the isolation of the Study Area, however it is not known habitat for this species. Potential impacts from isolation are likely to be reduced due to the highly mobile nature of this species.

c) Whether the species, or its habitat, are adequately represented in conservation reserves (or other similar protected areas) in the region.

There have been 19 records of the grey-headed flying fox (*Pteropus poliocephalus*) documented for Wollemi National Park (DEC 2006bn). Given that this species has only been recorded within one conservation reserve within the region, it is unlikely that this species is adequately protected.

d) Whether the species is at the limit of its known distribution.

This species has generally been recorded within 200 kilometres of the eastern coast, from Bundaberg in Queensland, through NSW and south to eastern Victoria. It has been recorded from Melbourne, some occurring west to Warrnambool (NSW Scientific Committee 2001h). Regular movements are made over the Great Dividing Range to the western slopes of NSW and Queensland. A record of this species from the Study Area would not represent an extension to the known distribution of this species, however records to the west of the Study Area are considered to be highly unusual for this species.

37. Yellow-bellied sheathtail bat – *Saccolaimus flaviventris*

The yellow-bellied sheathtail-bat (*Saccolaimus flaviventris*) is wide ranging throughout tropical Australia, with records extending into south eastern areas (Churchill 1998). In the most southerly part of its range - most of Victoria, south-western NSW and adjacent South Australia - it is a rare visitor in late summer and autumn. There are scattered records of this species across the New England Tablelands and North West Slopes (DEC 2006bo). Has been recorded from a wide variety of habitats, from wet and dry sclerophyll forest, open woodland, *Acacia* shrubland, mallee, grasslands and deserts (Churchill 1998). In eucalypt forests this species forages above the canopy, however ventures lower when in open country (Richards 1995a). This species is generally solitary, however may form small groups around spring (Churchill 1998). Roosting is generally recorded from tree hollows and buildings, however use mammal burrows in treeless areas (DEC 2006bo). When foraging for insects, these bats fly high and fast over the forest canopy, but lower in more open country. It forages in most habitats across its very wide range, with and without trees; appears to defend an aerial territory (DEC 2006bo). Seasonal movements are unknown; there is speculation about a migration to southern Australia in late summer and autumn (DEC 2006bo). A single young is born between December and March (Churchill 1998).

a) Whether the life cycle of the species is likely to be disrupted such that a local viable population of the species is likely to be placed at risk of extinction.

The yellow-bellied sheathtail bat (*Saccolaimus flaviventris*) was not recorded within the Study Area, despite extensive, seasonal surveys. The Study Area provides potential foraging habitat for this species, as well as potential roosting habitat in the form of small hollows and tree cavities. Due to the large amounts of seasonal survey completed, it is likely that this species would have been recorded if present in the Study Area. This is a highly mobile species, which is likely to make use of habitat within a number of vegetated areas within the region. It is considered that there is not a local viable population of this species centred within the Study Area.

It is considered unlikely that the Anvil Hill Project will result in the disruption of a local viable population of this species, such that it will be placed at risk of extinction.

b) In relation to the regional distribution of the habitat of the threatened species, whether a significant area of known habitat is to be modified or removed, or isolated from currently interconnecting or proximate areas.

Records of this species are scattered across New South Wales, with a small cluster of records from the Newcastle area. There are no further records of this species from the remainder of the Hunter Valley. There are a number of records inland from the Coonabarrabran area.

The large size of the Study Area, as well as the habitat types provided within it, suggest that if this species was recorded during surveys, this would be an important habitat area for this species within the region.

The Anvil Hill Project is likely to increase the isolation of the Study Area, however it is not known habitat for this species. Potential impacts from isolation are likely to be reduced due to the highly mobile nature of this species.

c) Whether the species, or its habitat, are adequately represented in conservation reserves (or other similar protected areas) in the region.

There have been no sightings of the yellow-bellied sheathtail bat (*Saccolaimus flaviventris*) recorded within any of the nine conservation reserves identified within the region surrounding the Study Area. As such, it is unlikely that this species is adequately represented in conservation reserves within the region.

d) Whether the species is at the limit of its known distribution.

The yellow-bellied sheathtail-bat (*Saccolaimus flaviventris*) is wide ranging throughout tropical Australia, with records extending into south eastern areas (Churchill 1998). In the most southerly part of its range - most of Victoria, south-western NSW and adjacent South Australia - it is a rare visitor in late summer and autumn. While a record of this species from the Study Area would not represent a distributional limit, it would certainly represent one of the very few records of this species from the Hunter Valley.

38. Eastern freetail-bat – *Mormopterus norfolkensis*

This species has a distribution along the east coast of NSW from south of Sydney north into south east Queensland, near Brisbane (Churchill 1998). Most records are from dry eucalypt forest and woodland east of the Great Dividing Range (DEC 2006al). This species has also been recorded over a rocky river in rainforest and wet sclerophyll forest (Churchill 1998). Generally only solitary animals are recorded (Allison & Hoye 2002). This species generally roosts in tree hollows, however have been recorded from roofs, under bark and the metal caps of telegraph poles (Churchill 1998). They generally forage above the forest canopy, over water and also on the ground.

a) Whether the life cycle of the species is likely to be disrupted such that a local viable population of the species is likely to be placed at risk of extinction.

The eastern freetail-bat (*Mormopterus norfolkensis*) was recorded within the Study Area on three occasions. From an analysis of known records of this species within the Study Area, the Anvil Hill Project will result in the overall loss of 58.9% of potential habitat (vegetation communities where this species was recorded) for this species.

The Study Area provides known foraging habitat for this species, as well as potential roosting and breeding habitat in the form of tree hollows and loose bark. As this species was recorded from the Study Area, there is the potential that the Study Area provides habitat for a resident population of this species. Nevertheless, it is likely that small numbers of this species would use the habitat within the Study Area periodically, as part of a larger range. The highly mobile nature of this species will allow it to make use of a range of habitat within the local area. Despite this mobility, the mere size of the Study Area in relation to other vegetation remnants in the local area suggests it is likely to be an important habitat resource for this species.

The Anvil Hill Project will require the removal of a large area of vegetation containing specific habitat requirements for this species. As the species is likely to be using such resources from a variety of locations within the local area, it is not likely that the species is entirely dependant on resources provided by the Study Area. However, the fact that a large proportion of known habitat within the Study Area will be removed suggests that there may be a significant loss of known foraging and potential roosting habitat to those eastern freetail-bats in the region. This impact is likely to disrupt the life cycle of this species, such that a local viable population of this species is likely to be placed at risk of extinction.

b) In relation to the regional distribution of the habitat of the threatened species, whether a significant area of known habitat is to be modified or removed, or isolated from currently interconnecting or proximate areas.

There are a number of records of this species within the Hunter Valley, with the majority being from the coastal regions. Records of this species further west along the valley are uncommon, with most being from the Singleton/Muswellbrook area.

The Anvil Hill Project will require the removal of a large area of vegetation containing specific habitat requirements for this species. As the species is likely to be using such resources from a variety of locations within the local area, it is not likely that the species is entirely dependant on resources provided by the Study Area.

The highly mobile nature of this species is likely to offset any impacts from increased isolation as a result of the Anvil Hill Project. However, the fact that a large proportion of known habitat within the Study Area will be removed suggests that there may be a significant loss of known foraging and potential roosting habitat to those eastern freetail-bats (*Mormopterus norfolkensis*) in the region.

c) Whether the species, or its habitat, are adequately represented in conservation reserves (or other similar protected areas) in the region.

There are 16 records of the eastern freetail-bat (*Mormopterus norfolkensis*) for Wollemi (DEC 2006al) and one record of this species within Manobalai Nature Reserve (NPWS Wildlife Atlas Database 2006).

Despite there being several records of eastern freetail-bat (*Mormopterus norfolkensis*) within conservation reserves in the region, available habitat for this species has substantially declined due to high rates of land clearance and degradation through mining and agricultural activities. As such, it is unlikely that this species is adequately protected within conservation reserves in the region.

d) Whether the species is at the limit of its known distribution.

This species has a distribution along the east coast of NSW from south of Sydney north into south east Queensland, near Brisbane (Churchill 1998). Most records are from dry eucalypt forest and woodland east of the Great Dividing Range (DEC 2006al). The record of this species within the Study Area represents one of the uncommon records of this species within the upper Hunter.

39. Eastern bentwing-bat – *Miniopterus schreibersii oceanensis*

This species has an eastern distribution from Cape York along the coastal side of the Great Dividing Range, and into the southern tip of South Australia (Churchill 1998). Habitat varies widely, from rainforest, wet and dry sclerophyll forest, monsoon forest, open woodland, paperbark forests and open grasslands (Churchill 1998). It is generally a cave-dwelling species, congregating in maternity caves with very specific temperature and humidity ranges (DEC 2006am). During the non-breeding season, this species will disperse to satellite caves, generally within 300 kilometres (Churchill 1998). Breeding or roosting colonies can number from 100 to 150,000 individuals (DEC 2006am).The eastern bentwing-bat (*Miniopterus schreibersii oceanensis*) hibernates over winter in the southern parts of its range (Churchill 1998). It has been recorded roosting in a variety of man-made structures including buildings and culverts (Dwyer 2002), as well as derelict mines and storm-water tunnels. A single young is born in December (Churchill 1998). The species hunts in forested areas, catching moths and other flying insects above the tree tops.

a) Whether the life cycle of the species is likely to be disrupted such that a local viable population of the species is likely to be placed at risk of extinction.

The eastern bentwing-bat (*Miniopterus schreibersii oceanensis*) was recorded within the Study Area on 12 occasions. From an analysis of known records of this species within the Study Area, the Anvil Hill Project will result in the overall loss of 58.6% of potential habitat (vegetation communities where this species was recorded) for this species.

The Study Area provides known foraging habitat for this species, as well as potential roosting and breeding habitat in the form of caves and rocky overhangs. Due to the records of this species, there is the potential that a colony of this species is resident within the Study Area. Field survey did record small numbers of bats roosting individually within some of the caves and overhangs on Limb of Addy Hill, however it was not possible to determine the species at the time. There is the potential that these records were eastern bentwing-bats. If so, it would be likely that a resident population was present within the Proposed Offset Areas, thus increasing the significance of the habitat within the Study Area for this species.

The highly mobile nature of this species suggests that it would use the habitat within the Study Area periodically, as part of a larger range covering the local area. Despite this mobility, the mere size of the Study Area in relation to other vegetation remnants in the local area suggests it is likely to be an important habitat resource for this species.

The Anvil Hill Project will require the removal of a large area of vegetation containing specific habitat requirements for this species. As the species is likely to be using such resources from a variety of locations within the local area, it is not likely that the species is entirely dependant on resources provided by the Study Area. However, the fact that a large proportion of known habitat within the Study Area will be removed suggests that there may be a significant loss of known foraging and potential roosting habitat to those eastern bentwing-bats in the region. This impact is likely to disrupt the life cycle of this species, such that a local viable population of this species may be placed at risk of extinction.

b) In relation to the regional distribution of the habitat of the threatened species, whether a significant area of known habitat is to be modified or removed, or isolated from currently interconnecting or proximate areas.

There is a large concentration of records of this species in the coastal areas of the Hunter Valley. Most of these records are from the Newcastle area. Records also exist further up the valley, however the number of these records diminishes further to the west.

The Anvil Hill Project will require the removal of a large area of vegetation containing specific habitat requirements for this species. As the species is likely to be using such resources from a variety of locations within the local area, it is not likely that the species is entirely dependant on resources provided by the Study Area.

The highly mobile nature of this species is likely to offset any impacts from increased isolation as a result of the Anvil Hill Project. However, the fact that a large proportion of known habitat within the Study Area will be removed suggests that there may be a significant loss of known foraging and potential roosting habitat to those eastern bentwing-bats (*Miniopterus schreibersii oceanensis*) in the region.

c) Whether the species, or its habitat, are adequately represented in conservation reserves (or other similar protected areas) in the region.

There has been one record of the eastern bentwing-bat (*Miniopterus schreibersii oceanensis*) occurring within Goulburn River National Park, 14 records of this species within Wollemi National Park, and one record in Manobalai Nature Reserve (DEC 2006am).

Despite there being several records of the eastern bentwing-bat within conservation reserves in the region, available habitat for this species has substantially declined due to high rates of land clearance and degradation through mining and agricultural activities. As such, it is unlikely that this species is adequately protected within conservation reserves in the region.

d) Whether the species is at the limit of its known distribution.

This species has an eastern distribution from Cape York along the coastal side of the Great Dividing Range, and into the southern tip of South Australia (Churchill 1998). The record of this species within the Study Area is approaching the western edge of the known distribution for this species.

40. Greater long-eared bat – *Nyctophilus timoriensis*

The greater long-eared bat (*Nyctophilus timoriensis*) is generally found in the semi-arid areas of southern Australia, including southern Queensland, NSW, Victoria, South Australia, southern Western Australia and Tasmania (Churchill 1998). This species inhabits a variety of vegetation types, including mallee, bulloak (*Allocasuarina luehmannii*) and box eucalypt dominated communities, but it is distinctly more common in box/ironbark/cypress-pine vegetation that occurs in a north-south belt along the western slopes and plains of NSW and southern Queensland (DEC 2006bp). Greater long-eared bats (*Nyctophilus timoriensis*) roost in tree hollows, fissures in branches and under the bark of trees (Churchill 1998). A single litter, commonly twins, is produced each year in late spring and early summer (Churchill 1998). This is a slow flying agile bat, utilising the understorey to hunt non-flying prey - especially caterpillars and beetles - and will even hunt on the ground (DEC 2006bp).

a) Whether the life cycle of the species is likely to be disrupted such that a local viable population of the species is likely to be placed at risk of extinction.

The greater long-eared bat (*Nyctophilus timoriensis*) was not identified within the Study Area, despite extensive, seasonal surveys. It is considered that a viable local population of this species is not likely to be present within the Study Area.

The Anvil Hill Project is unlikely to disrupt a local viable population of the species, such that the species is likely to be placed at risk of extinction.

b) In relation to the regional distribution of the habitat of the threatened species, whether a significant area of known habitat is to be modified or removed, or isolated from currently interconnecting or proximate areas.

There are very few records of this species within the Hunter Valley, with the majority of records coming from Goulburn River National Park. There is one record of this species from Manobalai Nature Reserve, and another from Turill State Forest. These are the only records of this species from the Hunter Valley.

The greater long-eared bat (*Nyctophilus timoriensis*) was not identified within the Study Area, despite extensive, seasonal surveys. The Study Area does not contain a significant area of known habitat for this species, and it is considered unlikely that this species is present within the Study Area.

A significant area of known habitat for this species will not be modified or removed, or isolated from currently interconnecting or proximate areas as a result of the Anvil Hill Project.

c) Whether the species, or its habitat, are adequately represented in conservation reserves (or other similar protected areas) in the region.

There are ten records of the greater long-eared bat (*Nyctophilus timoriensis*) occurring within Goulburn River National Park and one record within Manobalai Nature Reserve (DEC 2006bp).

Although present within two national parks within the region, the number of recorded sightings of the greater long-eared bat is very low. As such, it is unlikely that this species is adequately protected within conservation reserves in the region.

d) Whether the species is at the limit of its known distribution.

The greater long-eared bat (*Nyctophilus timoriensis*) is generally found in the semi-arid areas of southern Australia, including southern Queensland, NSW, Victoria, South Australia, southern Western Australia and Tasmania (Churchill 1998). A record of this species from the Study Area would not represent a distributional limit for the species, however would be an uncommon record in the Hunter Valley.

41. Little pied bat – *Chalinolobus picatus*

The little pied bat (*Chalinolobus picatus*) is found in inland Queensland, New South Wales (including the western plains and slopes) and South Australia with most records from west of the Great Dividing Range (Churchill 1998). The species has been recorded in dry open forest/woodland, Mulga woodlands, chenopod shrublands, *Callitris* forest and mallee (Churchill 1998). Roost habitat consists of tree hollows, caves, rocky outcrops and abandoned mines and houses (Churchill 1998). A single observation indicated that this species gives birth during November and feeds on moths (Churchill 1998). This species is known to tolerate high temperatures and dryness but need access to nearby open water (DEC 2006bq).

a) Whether the life cycle of the species is likely to be disrupted such that a local viable population of the species is likely to be placed at risk of extinction.

The little pied (*Chalinolobus picatus*) bat was not identified within the Study Area, despite extensive, seasonal surveys. It is considered that a local viable population of this species is not likely to be present within the Study Area.

The Anvil Hill Project is unlikely to disrupt a local viable population of the species, such that the species is likely to be placed at risk of extinction.

b) In relation to the regional distribution of the habitat of the threatened species, whether a significant area of known habitat is to be modified or removed, or isolated from currently interconnecting or proximate areas.

There are no records of this species from the Hunter Valley. The Gunnedah area represents the eastern limit of known records for this species.

The little pied bat (*Chalinolobus picatus*) was not identified within the Study Area, despite extensive, seasonal surveys. The Study Area does not contain a significant area of known habitat for this species, and it is considered unlikely that this species is present within the Study Area.

A significant area of known habitat for this species will not be modified or removed, or isolated from currently interconnecting or proximate areas as a result of the Anvil Hill Project.

c) Whether the species, or its habitat, are adequately represented in conservation reserves (or other similar protected areas) in the region.

There have been no sightings of the little pied bat (*Chalinolobus picatus*) recorded within any of the nine conservation reserves identified within the region surrounding the Study Area. As such, it is unlikely that this species is adequately represented in conservation reserves within the region.

d) Whether the species is at the limit of its known distribution.

The little pied bat (*Chalinolobus picatus*) is found in inland Queensland, New South Wales (including the western plains and slopes) and South Australia with most records from west of the Great Dividing Range (Churchill 1998). A record of this species from the Study Area would represent the only known record of this species from the Hunter Valley and would also represent the eastern-most record of this species from New South Wales.

42. Eastern false pipistrelle – *Falsistrellus tasmaniensis*

This species has a range from south eastern Queensland, through NSW and Victoria and into Tasmania (Churchill 1998). Habitat includes sclerophyll forest from the Great Dividing Range to the coast. This species prefers moist habitats, with trees taller than 20 metres (DEC 2006an). It generally roosts in tree hollows in groups of 6 – 36, but is occasionally recorded from caves or buildings (Churchill 1998). This species hunts beetles, moths, weevils and other flying insects above or just below the tree canopy. The eastern false pipistrelle (*Falsistrellus tasmaniensis*) appears to hibernate over winter in southern parts (Phillips 1995). A single young is born in December (Churchill 1998).

a) Whether the life cycle of the species is likely to be disrupted such that a local viable population of the species is likely to be placed at risk of extinction.

The eastern false pipistrelle (*Falsistrellus tasmaniensis*) was recorded within the Study Area on two occasions. From an analysis of known records of this species within the Study Area, the Anvil Hill Project will result in the overall loss of 60.4% of potential habitat (vegetation communities where this species was recorded) for this species.

The Study Area provides known foraging habitat for this species, as well as potential roosting and breeding habitat in the form of tree hollows and loose bark, or occasionally in caves. As this species was recorded from the Study Area, there is the potential that the Study Area provides habitat for a residential population of this species. Field survey did record small numbers of bats roosting individually within some of the caves and overhangs on Limb of Addy Hill, however it was not possible to determine the species at the time. There is the potential that these records were eastern false pipistrelles. It is likely that small numbers of this species would use the habitat within the Study Area periodically, as part of a larger range. The highly mobile nature of this species will allow it to make use of a range of habitat within the local area. Despite this mobility, the size of the Study Area in relation to other vegetation remnants in the local area suggests it is likely to be an important habitat resource for this species.

The Anvil Hill Project will require the removal of a large area of vegetation containing specific habitat requirements for this species. As the species is likely to be using such resources from a variety of locations within the local area, it is not likely that the species is entirely dependent on resources provided by the Study Area. However, the fact that a large proportion of known habitat within the Study Area will be removed suggests that there may be a significant loss of known foraging and potential roosting habitat to those eastern false pipistrelles (*Falsistrellus tasmaniensis*) in the region. This impact is likely to disrupt the life cycle of this species, such that a local viable population of this species may be placed at risk of extinction.

b) In relation to the regional distribution of the habitat of the threatened species, whether a significant area of known habitat is to be modified or removed, or isolated from currently interconnecting or proximate areas.

The majority of records for this species from the Hunter Valley are from the heavily-vegetated conservation reserves fringing the valley, such as Wollemi, Yengo and Goulburn River National Parks. There are a small number of records from the vegetated areas of the Cessnock district, however there are no further records of this species from the valley floor.

The Anvil Hill Project will require the removal of a large area of vegetation containing specific habitat requirements for this species. As the species is likely to be using such resources from a variety of locations within the local area, it is not likely that the species is entirely dependent on resources provided by the Study Area.

The highly mobile nature of this species is likely to offset any impacts from increased isolation as a result of the Anvil Hill Project. However, the fact that a large proportion of known habitat within the Study Area will be removed suggests that there will be a significant loss of known foraging and potential roosting habitat to those eastern false pipistrelles (*Falsistrellus tasmaniensis*) in the region.

c) Whether the species, or its habitat, are adequately represented in conservation reserves (or other similar protected areas) in the region.

Within Goulburn River National Park, there has been one record of the eastern false pipistrelle and there are 26 records of this species from within Wollemi National Park (DEC 2006an).

Although present within two of the larger national parks within the region, the number of recorded sightings of the eastern false pipistrelle is very low. As such, it is unlikely that this species is adequately protected within conservation reserves in the region.

d) Whether the species is at the limit of its known distribution.

This species has a range from south eastern Queensland, through NSW and Victoria and into Tasmania (Churchill 1998). Habitat includes sclerophyll forest from the Great Dividing Range to the coast. The record of this species from the Study Area is approaching the western edge of the known distribution for this species.

43. Large-eared pied bat – *Chalinolobus dwyeri*

The large-eared pied bat (*Chalinolobus dwyeri*) is found mainly in areas with extensive cliffs and caves, from Rockhampton in Queensland south to Bungonia in the NSW Southern Highlands (DEC 2006ao). It is generally rare with a very patchy distribution in NSW. There are scattered records from the New England Tablelands and North West Slopes (DEC 2006ao). It has been recorded frequenting low to mid-elevation dry open forest and woodland close roosting habitat (DEC 2006ao). It is found in well-timbered areas containing gullies, and is likely to tolerate a wide range of habitats (Hoye & Dwyer 2002). This species tends to roost in the twilight zones of mines and caves, generally in colonies or common groups (Churchill 1998), and is likely to hibernate through the coolest months (DEC 2006ao). Females have been recorded raising young in maternity roosts (c. 20-40 females) from November through to January in roof domes in sandstone caves. They remain loyal to the same cave over many years (DEC 2006ao). Females give birth (generally to twins) in November (Churchill 1998). The relatively short, broad wing combined with the low weight per unit area of wing indicates manoeuvrable flight. This species probably forages for small, flying insects below the forest canopy.

a) Whether the life cycle of the species is likely to be disrupted such that a local viable population of the species is likely to be placed at risk of extinction.

The large-eared pied bat (*Chalinolobus dwyeri*) was recorded within the Study Area on three occasions. From an analysis of known records of this species within the Study Area, the Anvil Hill Project will result in the overall loss of 42.3% of potential habitat (vegetation communities where this species was recorded) for this species.

The Study Area provides known foraging habitat for this species, as well as potential roosting and breeding habitat in the form of caves and rock overhangs. As this species was recorded from the Study Area, there is the potential that the Study Area provides habitat for a residential population of this species. Field survey did record small numbers of bats roosting individually within some of the caves and overhangs on Limb of Addy Hill, however it was not possible to determine the species at the time. There is the potential that these records were large-eared pied bats. It is likely that small numbers of this species would use the habitat within the Study Area periodically, as part of a larger range. The highly mobile nature of this species will allow it to make use of a range of habitat within the local area. Despite this mobility, the size of the Study Area in relation to other vegetation remnants in the local area suggests it is likely to be an important habitat resource for this species.

The Anvil Hill Project will require the removal of a large area of vegetation containing specific habitat requirements for this species. As the species is likely to be using such resources from a variety of locations within the local area, it is not likely that the species is entirely dependent on resources provided by the Study Area. However, the fact that a large proportion of known habitat within the Study Area will be removed suggests that there may be a significant loss of known foraging and potential roosting habitat to those large-eared pied bats in the region. This impact is likely to disrupt the life cycle of this species, such that a local viable population of this species may be placed at risk of extinction.

b) In relation to the regional distribution of the habitat of the threatened species, whether a significant area of known habitat is to be modified or removed, or isolated from currently interconnecting or proximate areas.

There are not a large number of records of this species from the floor of the Hunter Valley, however there are a number of records from the heavily-vegetated conservation reserves nearby. There are a small number of records from the Newcastle and Maitland areas.

The Anvil Hill Project will require the removal of a large area of vegetation containing specific habitat requirements for this species. As the species is likely to be using such resources from a variety of locations within the local area, it is not likely that the species is entirely dependent on resources provided by the Study Area.

The highly mobile nature of this species is likely to offset any impacts from increased isolation as a result of the Anvil Hill Project. However, the fact that a large proportion of known habitat within the Study Area will be removed suggests that there may be a significant loss of known foraging and potential roosting habitat to those large-eared pied bats (*Chalinolobus dwyeri*) in the region.

c) Whether the species, or its habitat, are adequately represented in conservation reserves (or other similar protected areas) in the region.

There are nine records of the large-eared pied bat (*Chalinolobus dwyeri*) for the Goulburn River National Park and 52 records of this species for Wollemi National Park (DEC 2006ao).

Despite there being several records of the large-eared pied bat (*Chalinolobus dwyeri*) within conservation reserves in the region, available habitat for this species has substantially declined due to high rates of land clearance and degradation through mining and agricultural activities. As such, it is unlikely that this species is adequately protected within conservation reserves in the region.

d) Whether the species is at the limit of its known distribution.

The large-eared pied bat (*Chalinolobus dwyeri*) is found mainly in areas with extensive cliffs and caves, from Rockhampton in Queensland south to Bungonia in the NSW Southern Highlands (DEC 2006ao). It is generally rare with a very patchy distribution in NSW. There are scattered records from the New England Tablelands and North West Slopes (DEC 2006ao). The records of this species within the Study Area do not represent a distributional limit for this species, however are some of the few records of this species from the valley floor.

44. Large-footed myotis – *Myotis adversus*

This is a coastal species, ranging from the Kimberley to South Australia (Churchill 1998). It is rarely found more than 100 kilometres inland, except along major rivers (DEC 2006ap). It will occur in most habitat types providing they are near to water (Richards 1995b). It will forage over streams and pools catching insects and small fish by raking their feet across the water surface (DEC 2006ap). This species is commonly cave-dwelling in groups of 10 to 15, however it is also recorded from tree hollows, dense vegetation, bridges, mines and drains (Churchill 1998). When breeding, it roosts in small groups, with males defending a territory and a harem of females (Richards 1995b). A single young is born in November through to December (Churchill 1998).

a) Whether the life cycle of the species is likely to be disrupted such that a local viable population of the species is likely to be placed at risk of extinction.

The large-footed myotis (*Myotis adversus*) was recorded within the Study Area on three occasions. From an analysis of known records of this species within the Study Area, the Anvil Hill Project will result in the overall loss of 63.6% of potential habitat (vegetation communities where this species was recorded) for this species.

The Study Area provides known foraging habitat for this species, as well as potential roosting and breeding habitat in the form of tree hollows, rock overhangs and loose bark. As this species was recorded from the Study Area, there is the potential that the Study Area provides habitat for a residential population of this species. Field survey did record small numbers of bats roosting individually within some of the caves and overhangs on Limb of Addy Hill, however it was not possible to determine the species at the time. There is the potential that these records were large-footed myotis. It is likely that small numbers of this species would use the habitat within the Study Area periodically, as part of a larger range. The highly mobile nature of this species will allow it to make use of a range of habitat within the local area. Despite this mobility, the size of the Study Area in relation to other vegetation remnants in the local area suggests it is likely to be an important habitat resource for this species.

The Anvil Hill Project will require the removal of a large area of vegetation containing specific habitat requirements for this species. As the species is likely to be using such resources from a variety of locations within the local area, it is not likely that the species is entirely dependent on resources provided by the Study Area. However, the fact that a large proportion of known habitat within the Study Area will be removed suggests that there will be a significant loss of known foraging and potential roosting habitat to those large-footed myotis in the region. This impact is likely to disrupt the life cycle of this species, such that a local viable population of this species may be placed at risk of extinction.

b) In relation to the regional distribution of the habitat of the threatened species, whether a significant area of known habitat is to be modified or removed, or isolated from currently interconnecting or proximate areas.

The majority of records of this species are from the Hunter Valley are from coastal regions, surrounding Newcastle and Raymond Terrace. There are a small number of records from the Ravensworth area, further up the valley.

The Anvil Hill Project will require the removal of a large area of vegetation containing specific habitat requirements for this species. As the species is likely to be using such resources from a variety of locations within the local area, it is not likely that the species is entirely dependent on resources provided by the Study Area.

The highly mobile nature of this species is likely to offset any impacts from increased isolation as a result of the Anvil Hill Project. However, the fact that a large proportion of known habitat within the Study Area will be removed suggests that there may be a significant loss of known foraging and potential roosting habitat to those large-footed myotis (*Myotis adversus*) in the region.

c) Whether the species, or its habitat, are adequately represented in conservation reserves (or other similar protected areas) in the region.

There are two records of the large-footed myotis (*Myotis adversus*) occurring within Wollemi National Park (DEC 2006ap). Given that this species has only been recorded within one conservation reserve within the region, it is unlikely that this species is adequately protected.

d) Whether the species is at the limit of its known distribution.

This is a coastal species, ranging from the Kimberley to South Australia (Churchill 1998). It is rarely found more than 100 kilometres inland, except along major rivers (DEC 2006ap). It will occur in most habitat types providing they are near to water (Richards 1995). The records of this species within the Study Area are uncharacteristically far from the coast, and are likely to represent a westerly extension to the known distribution of this species.

45. Greater broad-nosed bat – *Scoteanax rueppellii*

The greater broad-nosed bat (*Scoteanax rueppellii*) is found mainly in the gullies and river systems that drain the Great Dividing Range, from north-eastern Victoria to the Atherton Tableland. It extends to the coast over much of its range. In NSW it is widespread on the New England Tablelands, however it does not occur at altitudes above 500 metres (DEC 2006aq). This species occurs in moist gullies and river systems draining the Great Dividing Range, as well as a variety of woodland, forest and rainforest habitats (Hoye & Richards 2002). It has been recorded roosting in hollow tree trunks and branches, as well as old buildings (Churchill 1998). This species forages after sunset, flying slowly and directly along creek and river corridors at an altitude of 3 - 6 metres. Open woodland habitat and dry open forest suits the direct flight of this species as it searches for beetles and other large, slow-flying insects; this species has been known to eat other bat species (DEC 2006aq). Little is known of the reproductive cycle of the species, however, females congregate at maternity sites, located in suitable trees, where they appear to exclude males for the birth and raising of the single young in January (Hoye & Richards 2002).

a) Whether the life cycle of the species is likely to be disrupted such that a local viable population of the species is likely to be placed at risk of extinction.

The greater broad-nosed bat (*Scoteanax rueppellii*) was recorded within the Study Area on one occasion. From an analysis of known records of this species within the Study Area, the Anvil Hill Project will result in the overall loss of 99.5% of potential habitat (vegetation communities where this species was recorded) for this species.

The Study Area provides known foraging habitat for this species, as well as potential roosting and breeding habitat in the form of tree hollows and loose bark. It has been recorded roosting in old buildings. As this species was recorded from the Study Area, there is the potential that the Study Area provides habitat for a resident population of this species. Field survey did record small numbers of bats roosting individually within some of the caves and overhangs on Limb of Addy Hill, however it was not possible to determine the species at the time. There is the potential that these records were greater broad-nosed bats. It is likely that small numbers of this species would use the habitat within the Study Area periodically, as part of a larger range. The highly mobile nature of this species will allow it to make use of a range of habitat within the local area. Despite this mobility, the size of the Study Area in relation to other vegetation remnants in the local area suggests it is likely to be an important habitat resource for this species.

The Anvil Hill Project will require the removal of a large area of vegetation containing specific habitat requirements for this species. As the species is likely to be using such resources from a variety of locations within the local area, it is not likely that the species is entirely dependent on resources provided by the Study Area. However, the fact that a large proportion of known habitat within the Study Area will be removed suggests that there may be a significant loss of known foraging and potential roosting habitat to those greater broad-nosed bats in the region. This impact is likely to disrupt the life cycle of this species, such that a local viable population of this species may be placed at risk of extinction.

b) In relation to the regional distribution of the habitat of the threatened species, whether a significant area of known habitat is to be modified or removed, or isolated from currently interconnecting or proximate areas.

The majority of records of this species are from the Hunter Valley are from coastal regions, surrounding Newcastle, Maitland and Raymond Terrace. There are a small number of records further along the valley, from Barrington Tops National Park, and a single record near Jerrys Plains.

The Anvil Hill Project will require the removal of a large area of vegetation containing specific habitat requirements for this species. As the species is likely to be using such resources from a variety of locations within the local area, it is not likely that the species is entirely dependent on resources provided by the Study Area.

The highly mobile nature of this species is likely to offset any impacts from increased isolation as a result of the Anvil Hill Project. However, the fact that a large proportion of known habitat within the Study Area will be removed suggests that there may be a significant loss of known foraging and potential roosting habitat to those greater broad-nosed bats (*Scoteanax rueppellii*) in the region.

c) Whether the species, or its habitat, are adequately represented in conservation reserves (or other similar protected areas) in the region.

The greater broad-nosed bat (*Scoteanax rueppellii*) has been recorded within Wollemi National Park, with nine sightings being documented (DEC 2006aq). Given that this species has only been recorded within one conservation reserve within the region, it is unlikely that this species is adequately protected.

d) Whether the species is at the limit of its known distribution.

The greater broad-nosed bat (*Scoteanax rueppellii*) is found mainly in the gullies and river systems that drain the Great Dividing Range, from north-eastern Victoria to the Atherton Tableland. It extends to the coast over much of its range. In NSW it is widespread on the New England Tablelands, however does not occur at altitudes above 500 metres (DEC 2006aq). This species occurs in moist gullies and river systems draining the Great Dividing Range. The records of this species within the Study Area would represent a westerly extension to the known distribution of this species within the upper Hunter.

46. Eastern cave bat – *Vespadelus troughtoni*

This species has been recorded in a broad band along eastern Australia on both sides of the Great Dividing Range, from Cape York to Kempsey (Churchill 1998). There are additional records of this species from the New England Tablelands and the upper north coast of NSW. The western limit appears to be the Warrumbungle Range, and there is a single record from southern NSW, east of the ACT (DEC 2006ar). This cave roosting species is known from drier forests and tropical woodlands from the coastal zone and Great Dividing Range to the semi-arid zone (Parnaby 2002). It is usually found in dry open forest and woodland, near cliffs or rocky overhangs, and has been recorded roosting in disused mine workings, occasionally in colonies of up to 500 individuals (DEC 2006ar). It is occasionally recorded roosting in buildings (Parnaby 2002). It is occasionally found along cliff-lines in wet eucalypt forest and rainforest. Roost sites are frequently in well-lit areas. Little further is known about their biology, including its feeding or breeding requirements, or behaviour (DEC 2006ar).

a) Whether the life cycle of the species is likely to be disrupted such that a local viable population of the species is likely to be placed at risk of extinction.

The eastern cave bat (*Vespadelus troughtoni*) was recorded within the Study Area on ten occasions. From an analysis of known records of this species within the Study Area, the Anvil Hill Project will result in the overall loss of 61.9% of potential habitat (vegetation communities where this species was recorded) for this species.

The Study Area provides known foraging habitat for this species, as well as potential roosting and breeding habitat in the form of caves and rock overhangs. As this species was recorded from the Study Area, there is the potential that the Study Area provides habitat for a resident population of this species. Field survey did record small numbers of bats roosting individually within some of the caves and overhangs on Limb of Addy Hill, however it was not possible to determine the species at the time. There is the potential that these records were eastern cave bats. It is likely that small numbers of this species would use the habitat within the Study Area periodically, as part of a larger range. The highly mobile nature of this species will allow it to make use of a range of habitat within the local area. Despite this mobility, the size of the Study Area in relation to other vegetation remnants in the local area suggests it may be an important habitat resource for this species.

The Anvil Hill Project will require the removal of a large area of vegetation containing specific habitat requirements for this species. As the species is likely to be using such resources from a variety of locations within the local area, it is not likely that the species is entirely dependent on resources provided by the Study Area. However, the fact that a large proportion of known habitat within the Study Area will be removed suggests that there may be a significant loss of known foraging and potential roosting habitat to those eastern cave bats in the region. This impact is likely to disrupt the life cycle of this species, such that a local viable population of this species may be placed at risk of extinction.

b) In relation to the regional distribution of the habitat of the threatened species, whether a significant area of known habitat is to be modified or removed, or isolated from currently interconnecting or proximate areas.

There are very few records of this species from New South Wales, with most concentrated in the north eastern corner of the state. There are a small number of records from the Hunter Valley, these coming from the western parts of Goulburn River National Park, and Manobalai Nature Reserve.

The Anvil Hill Project will require the removal of a large area of vegetation containing specific habitat requirements for this species. As the species is likely to be using such resources from a variety of locations within the local area, it is not likely that the species is entirely dependent on resources provided by the Study Area.

The highly mobile nature of this species is likely to offset any impacts from increased isolation as a result of the Anvil Hill Project. However, the fact that a large proportion of known habitat within the Study Area will be removed suggests that there may be a significant loss of known foraging and potential roosting habitat to those eastern cave bats (*Vespadelus troughtoni*) in the region.

c) Whether the species, or its habitat, are adequately represented in conservation reserves (or other similar protected areas) in the region.

There are ten records of the eastern cave bat (*Vespadelus troughtoni*) within Goulburn River National Park (DEC 2006ar), and one record within both Manobalai Nature Reserve and Wollemi National Park (DEC 2006ar).

Despite the eastern cave bat being recorded within three of the larger conservation reserves in the region, available habitat for this species has substantially declined due to high rates of land clearance and degradation through mining and agricultural activities. As such, it is unlikely that this species is adequately protected within conservation reserves in the region.

d) Whether the species is at the limit of its known distribution.

This species has been recorded in a broad band along eastern Australia on both sides of the Great Dividing Range, from Cape York to Kempsey (Churchill 1998). There are additional records of this species from the New England Tablelands and the upper north coast of NSW. The western limit appears to be the Warrumbungle Range, and there is a single record from southern NSW, east of the ACT (DEC 2006ar). The records of this species within the Study Area represent one of the few scattered records of this species within NSW. This record forms part of a small, isolated cluster of records covering parts of Wollemi and Goulburn River National Parks, and surrounding areas.

47. *Commersonia rosea*

This species is a prostrate shrub 0.1-0.3 metres high, producing trailing branches up to 60 cm long (Bell & Copeland 2004). Flowering has been observed in August, November, January and February (Bell & Copeland 2004). *Commersonia rosea* is only known from four localities in the Sandy Hollow district of the upper Hunter Valley, New South Wales, all locations being within an 8 kilometre radius of Sandy Hollow (DEC 2006ac). This species has been recorded from skeletal sandy soils derived from Triassic Narrabeen sandstone, in scrub or heath vegetation (Bell & Copeland 2004). It is believed to be fire-ephemeral, flowering and fruiting only after disturbance has occurred (Bell & Copeland 2004). *Commersonia rosea* occupies relatively small areas at its known sites and has a total population of less than 200 plants (DEC 2006ac). None of the known populations of this species are within conservation reserves (DEC 2006ac).

a) Whether the life cycle of the species is likely to be disrupted such that a local viable population of the species is likely to be placed at risk of extinction.

Commersonia rosea was recorded within the Study Area on one occasion. From an analysis of known records of this species within the Study Area, the Anvil Hill Project will result in the overall loss of none of the known habitat (vegetation communities where this species was recorded) for this species.

The Study Area provides known habitat for this species, including a population of this species. The location of known habitat suggests that further records of this species could be found in other parts of the Study Area, however most of these are likely to be in the Proposed Offset Areas, around sandstone outcrops and footslopes.

This species is known to be fire ephemeral, and at least three of the known populations of this species outside of the Study Area have been found in areas of recent fire. It is likely this species requires fire (or other forms of disturbance) for flowering. As the very small (two plants) population recorded from the Study Area is located near to a recently constructed fenceline, there is the potential that such recent disturbance has encouraged growth of this species.

This species was recorded from a very small population of two plants, approximately 700 metres south of the Proposed Disturbance Area, within the Proposed Offset Areas. There is the potential that this species would occur as small, discrete populations around sandstone outcrops and footslopes primarily in the Proposed Offset Areas. However, potential habitat also exists around Wallaby Rocks in the Proposed Disturbance Area, as well as around Anvil Hill and other sandstone outcrops in the local area.

The Anvil Hill Project will require the removal of a large area of vegetation within the Proposed Disturbance Area. As this species was only recorded within the Proposed Offset Areas, no known plants will be impacted by the Anvil Hill Project. There is the potential that this species occurs in other parts of the Study Area, particularly around sandstone outcrops and footslopes, however the majority of these features are located within the Proposed Offset Areas. If this species was present within the Proposed Disturbance Area, it is likely to be only very small numbers. It is unlikely that the Anvil Hill Project will disrupt the life cycle of this species, such that a local viable population of this species is likely to be placed at risk of extinction.

b) In relation to the regional distribution of the habitat of the threatened species, whether a significant area of known habitat is to be modified or removed, or isolated from currently interconnecting or proximate areas.

The only records of this species are from a small area in the Sandy Hollow area of the Hunter Valley. There are no further records of this species from New South Wales.

As this species was only recorded from the Proposed Offset Areas, the potential impact from the Anvil Hill Project will be minimal. While there is potential habitat for this species within the Proposed Disturbance Area, this habitat is limited to small sandstone outcrops and nearby footslopes. These areas are not likely to be impacted by the Anvil Hill Project. If this species was present within the Proposed Disturbance Area, it is expected that these would be very small numbers. It is unlikely that the Anvil Hill Project will cause a significant area of known habitat to be modified or removed, or isolated from currently interconnecting or proximate areas of known habitat for this species.

c) Whether the species, or its habitat, are adequately represented in conservation reserves (or other similar protected areas) in the region.

There are no records of *Commersonia rosea* documented for any of the nine conservation reserves identified within the region surrounding the Study Area. As such, this species is inadequately represented in conservation reserves within the region.

d) Whether the species is at the limit of its known distribution.

Commersonia rosea is only known from four localities in the Sandy Hollow district of the upper Hunter Valley, New South Wales, all locations being within an 8 kilometre radius of Sandy Hollow (DEC 2006ac), as well as the additional fifth population recorded in the Proposed Offset Areas. The records for this species from the Study Area represent a north-eastern extension to the highly restricted distribution of this species. This is likely to represent a 50% extension to the known range of this species.

48. *Cynanchum elegans*

Cynanchum elegans is a climber or twiner with stems to approximately one metre long (Harden & Williams 1992). Flowering occurs between August and May, with a peak in November (NSW NPWS 2002a). This species is restricted to eastern NSW where it is distributed from Brunswick Heads on the north coast to Gerroa in the Illawarra region. The species has been recorded as far west as Merriwa in the upper Hunter River Valley (DEC 2006), although it is likely that the record of this species at Mount Dangar, near Merriwa, is incorrect (Peake 2006). The species has been recorded from rainforest gullies and scree slopes (Harden & Williams 1992), but is thought to mainly occur at the ecotone between dry rainforest and sclerophyll forest or woodland (NSW NPWS 2002a). The species has been recorded in dry subtropical rainforest, littoral rainforest, coastal scrub (containing coast tea tree (*Leptospermum laevigatum)* and coast banksia (*Banksia integrifolia* subsp. *integrifolia*)), open forest and woodland (containing forest red gum (*Eucalyptus tereticornis)* and spotted gum (*Corymbia maculata*)) and open scrub (containing bracelet honey-myrtle (*Melaleuca armillaris*)). Within the Hunter Valley, this species has been recorded from Wollemi and Goulburn River National Parks.

a) Whether the life cycle of the species is likely to be disrupted such that a local viable population of the species is likely to be placed at risk of extinction.

Cynanchum elegans was not identified within the Study Area, despite extensive, seasonal surveys. It is considered that a local viable population of this species is not likely to be present within the Study Area.

The Anvil Hill Project is unlikely to disrupt a local viable population of the species, such that the species is likely to be placed at risk of extinction.

b) In relation to the regional distribution of the habitat of the threatened species, whether a significant area of known habitat is to be modified or removed, or isolated from currently interconnecting or proximate areas.

Cynanchum elegans was not identified within the Study Area, despite extensive, seasonal surveys. The Study Area does not contain a significant area of known habitat for this species, and it is considered unlikely that this species is present within the Study Area.

A significant area of known habitat for this species will not be modified or removed, or isolated from currently interconnecting or proximate areas as a result of the Anvil Hill Project.

There are a small number of records of this species from the Hunter Valley region. These records are generally scattered, however there is a dubious record in Goulburn River National Park, south of Gungal. The remaining records of this species within the Hunter Valley are single records from the Newcastle and Maitland areas.

c) Whether the species, or its habitat, are adequately represented in conservation reserves (or other similar protected areas) in the region.

There are two records of *Cynanchum elegans* documented within both Goulburn River National Park and Wollemi National Park (DEC 2006br), the former being dubious

(Peake 2006). There are less than 1000 plants known to occur within a conservation reserve over its entire range (Briggs and Leigh 1995). Due to the extent of region-wide landscape disturbance, potential habitat for this species has been greatly reduced. Given the low number of records of *Cynanchum elegans* within conservation reserves, and the reduction in potential habitat, it is unlikely that this species is adequately protected.

d) Whether the species is at the limit of its known distribution.

This species is restricted to eastern NSW where it is distributed from Brunswick Heads on the north coast to Gerroa in the Illawarra region. The species has been recorded as far west as Merriwa in the upper Hunter River Valley (DEC 2006br). A record of this species from the Study Area would represent an addition to the small number of records in this region, however would not represent a distributional limit of this species in the Hunter Valley, or in New South Wales.

49. Small snake orchid - *Diuris pedunculata*

The small snake orchid (*Diuris pedunculata)* is a terrestrial herb flowering August to September (Jones 1993b). This species is confined to New South Wales, where it was originally found scattered from Tenterfield south to the Hawkesbury River, but is now mainly found on the New England Tablelands, around Armidale, Uralla, Guyra and Ebor (DEC 2006bs). The small snake orchid is known to occur from Port Jackson to Tenterfield in the North Coast, Central Coast and Northern Tablelands botanical subdivisions (Jones 1993b). This species grows on grassy slopes or flats, however is often found on peaty soils in moist areas. It is also recorded from shale and trap soils, on fine granite, and among boulders (DEC 2006bs). Flowering has been recorded from August to October.

a) Whether the life cycle of the species is likely to be disrupted such that a local viable population of the species is likely to be placed at risk of extinction.

The small snake orchid (*Diuris pedunculata)* was not identified within the Study Area, despite extensive, seasonal surveys. It is considered that a local viable population of this species is not likely to be present within the Study Area.

The Anvil Hill Project is unlikely to disrupt a local viable population of the species, such that the species is likely to be placed at risk of extinction.

b) In relation to the regional distribution of the habitat of the threatened species, whether a significant area of known habitat is to be modified or removed, or isolated from currently interconnecting or proximate areas.

The small snake orchid (*Diuris pedunculata)* was not identified within the Study Area, despite extensive, seasonal surveys. The Study Area does not contain a significant area of known habitat for this species, and it is considered unlikely that this species is present within the Study Area.

A significant area of known habitat for this species will not be modified or removed, or isolated from currently interconnecting or proximate areas as a result of the Anvil Hill Project.

There are a small number of records of this species from the Hunter Valley. These records are generally scattered, however they all are recorded from the valley floor. The records of this species within the Hunter Valley are mainly scattered single records from the Kurri Kurri, Paterson, Clarencetown, Scone and Gungal areas.

c) Whether the species, or its habitat, are adequately represented in conservation reserves (or other similar protected areas) in the region.

There are no records of the small snake orchid (*Diuris pedunculata)* documented for any of the nine conservation reserves identified within the region surrounding the Study Area. As such, it is unlikely that this species is adequately protected within conservation reserves in the region.

d) Whether the species is at the limit of its known distribution.

This species is confined to New South Wales, where it was originally found scattered from Tenterfield south to the Hawkesbury River, but is now mainly found on the New England Tablelands, around Armidale, Uralla, Guyra and Ebor (DEC 2006bs). The small snake orchid (*Diuris pedunculata)* is known to occur from Port Jackson to Tenterfield in the North Coast, Central Coast and Northern Tablelands botanical subdivisions (Jones 1993b). A record of this species from the Study Area would be an uncommon record of this species in the Hunter Valley, however would not represent a distributional limit of this species.

50. Painted diuris – *Diuris tricolor*

Painted diuris (*Diuris tricolour)* is a terrestrial herb flowering September to November (Jones 1993b). Painted diuris grows in sclerophyll forest among grass and is often found with *Callitris* (Jones 1993b). It has been recorded on the Northern and Central Tablelands and Slopes (Jones 1993b), and is found in sandy soils, either on flats or small rises. This species has also been recorded from red earth soil in a bimble box (*Eucalyptus populnea*) community in western NSW (DEC 2006bt). This species is sporadically distributed on the western slopes of NSW, extending from south of Narrandera to the far north of NSW. Localities include the Condobolin-Nymagee Road, Wattamondara towards Cowra, Cooyal, Adelong, Red Hill north of Narrandera, Coolamon, near Darlington Point, Eugowra, Girilambone, Dubbo, Muswellbrook, and several sites west of Wagga Wagga (DEC 2006bt). The Muswellbrook local government area is the eastern limit of the species range and the only recorded occurrence of painted diuris in the Sydney Basin Bioregion (Australia's Virtual Herbarium 2006). The painted diuris population in Muswellbrook appears to be an isolated population and therefore this population may be genetically distinct. The species is considered likely to have declined in recent years and is threatened by the spread of invasive, exotic grasses, such as Coolatai grass (*Hyparrhenia hirta*) (Peake 2005).

a) Whether the life cycle of the species is likely to be disrupted such that a local viable population of the species is likely to be placed at risk of extinction.

Painted diuris *(Diuris tricolor)* was not recorded within the Study Area, however it was recorded from nearby grassland in the Proposed Offset Areas. It is considered that potential habitat for this species exists across the Grassland habitats of the Study Area. From an analysis of known records of this species outside of the Study Area, the Anvil Hill Project will result in the overall loss of 51.7% of potential habitat (vegetation communities where this species was recorded) for this species within the Study Area.

The Study Area provides some habitat for this species, mainly within the Proposed Disturbance Area. As this species is particularly difficult to identify, it is likely that this species would be present more abundantly than recorded within the Proposed Disturbance Area. If this were so, there is the potential that a (possibly) large population of this species could be removed as a result of the Anvil Hill Project.

The Anvil Hill Project will require the removal of a large area of vegetation within the Proposed Disturbance Area. There is a moderate chance that this species could occur within the Proposed Disturbance Area as a large population, there is a reasonable chance that the Anvil Hill Project could place a (potential) population of this species at risk of extinction. It is likely that the Anvil Hill Project will disrupt the life cycle of this species, such that a local viable population of this species may be placed at risk of extinction.

b) In relation to the regional distribution of the habitat of the threatened species, whether a significant area of known habitat is to be modified or removed, or isolated from currently interconnecting or proximate areas.

There are only a small number of records of this species from the Hunter Valley, with the majority of these records being from a small cluster around Muswellbrook. An outlying record exists from south of Gungal.

There is the potential that a population of this species could be placed at risk of extinction. In particular, the Anvil Hill Project would have the potential to fragment a population of this species, thus further increasing the risk of local extinction. It is likely that the Anvil Hill Project could cause a significant area of potential habitat to be modified or removed, or isolated from currently interconnecting or proximate areas of known habitat for this species.

c) Whether the species, or its habitat, are adequately represented in conservation reserves (or other similar protected areas) in the region.

Painted diuris (*Diuris tricolor)* has been recorded as being present within a conservation reserve(s) within the region (Briggs and Leigh 1995), however there are no records stating which reserve(s) the species occurs in. Given the lack of records available, the specific habitat requirements of this species, the extensive disturbance of habitat from mining and agricultural practices within the region, it is unlikely that this species is adequately represented within conservation reserves.

d) Whether the species is at the limit of its known distribution.

This species is sporadically distributed on the western slopes of NSW, extending from south of Narrandera to the far north of NSW. Localities include the Condobolin-Nymagee road, Wattamondara towards Cowra, Cooyal, Adelong, Red Hill north of Narrandera, Coolamon, near Darlington Point, Eugowra, Girilambone, Dubbo, Muswellbrook, and several sites west of Wagga Wagga (DEC 2006bt). The Muswellbrook local government area is the eastern limit of the species' range and the only recorded occurrence of painted diuris (*Diuris tricolor*) in the Sydney Basin Bioregion. The record of this species from the Study Area is likely to be at, or approaching, the eastern limit of the known distribution of this species.

51. Narrow goodenia - *Goodenia macbarronii*

Narrow goodenia (*Goodenia macbarronii)* is a small, annual herb to 30 cm high with peak flowering time occurring October to March (Carolin 1992). Narrow goodenia grows in damp sandy soils in seepages. The species is usually found in shaded, seasonally damp sites in clay-loam, sandy-loam and sandy soils. Habitats in NSW include a recently graded roadside drain adjacent to narrow-leaved ironbark (*Eucalyptus crebra*) and white cypress pine (*Callitris glaucophylla*) woodland, dry eucalypt forest with low shrubby undergrowth in sandy soil, damp sandy patches in bushland areas, along roadsides, near water in a shallow excavation which has exposed the clay subsoil, on the banks of a sandy creek and in Blakely's red gum (*Eucalyptus blakelyi*) and rough-barked apple (*Angophora floribunda*) woodland (DEC 2006d). Sites often have some form of recent disturbance, such as depressions made by grading and excavation along roadsides. Other sites include grazed paddocks and clearings with a large proportion of weed and exotic species, and cleared open grazing land which was formerly eucalypt woodland (DEC 2006d). This species grows on the western slopes of the Great Dividing Range in NSW, south from the Guyra and Inverell districts. It is widely distributed throughout the tablelands, western slopes and western plains. The species also occurs in north-eastern Victoria and the Darling Downs in Queensland (DEC 2006d). In NSW it has been recorded at Tingha, Guyra, the Warrumbungle Ranges, east of Rylstone, the Pilliga and Denobollie State Forests, the Narrabri, Coonabarabran, Torrington and Tocumwal districts, Grenfell, Weddin Mountain, Gungal, the Milthorpe district, and Holbrook (the Type locality) (DEC 2006d). In the Hunter Valley, the species is only known to occur in the Wybong district where several sub-populations have been recorded (Peake 2006).

a) Whether the life cycle of the species is likely to be disrupted such that a local viable population of the species is likely to be placed at risk of extinction.

Narrow goodenia (*Goodenia macbarronii)* was recorded within the Study Area on 12 occasions. From an analysis of known records of this species within the Study Area, the Anvil Hill Project will result in the overall loss of 57.0% of potential habitat (vegetation communities where this species was recorded) for this species.

The records of this species represent point records (from Umwelt and HLA) and area records (from HLA). The nature of the area records comes from the lack of specific point data on the locations of these records, as HLA (2002) made reference to undefined populations of this species. Some of the HLA data for this species was supplied merely as a region drawn on a map, with no supporting data, species numbers or coordinates.

A number of populations of this species were recorded from the Study Area. All of these records were from the Proposed Disturbance Area. A large amount of vegetation within the Proposed Disturbance Area will be removed. This will include all narrow goodenia records identified within the Study Area. These records within the Proposed Disturbance Area may represent the largest area of known habitat for this species in the Hunter Region. This is likely to disrupt the lifecycle of the species such that a local viable population of the species is likely to be placed at risk of extinction.

b) In relation to the regional distribution of the habitat of the threatened species, whether a significant area of known habitat is to be modified or removed, or isolated from currently interconnecting or proximate areas.

There are only a small number of records of this species from the Hunter Valley, with the majority of these being located in the large vegetation remnant containing Manobalai Nature Reserve.

As all of the records of this species were from the Proposed Disturbance Area, the Anvil Hill Project may place this population at risk of local extinction. There are records of populations of this species outside of the Study Area, within the local area. The loss of the large population of this species within the Proposed Disturbance Area is likely to increase the fragmentation and isolation of those known local populations. It is likely that the Anvil Hill Project will cause a significant area of known habitat to be modified or removed, or isolated from currently interconnecting or proximate areas of known habitat for this species.

c) Whether the species, or its habitat, are adequately represented in conservation reserves (or other similar protected areas) in the region.

Narrow goodenia (*Goodenia macbarronii*) has been recorded as being present within a conservation reserve(s) within the region (Briggs and Leigh 1995), however there are no records stating which reserve(s) the species occurs in. Given the lack of records available, in addition to the extensive disturbance of potential habitat for this species as a result of mining and agricultural practices within the region, it is unlikely that this species is adequately represented within conservation reserves.

d) Whether the species is at the limit of its known distribution.

This species grows on the western slopes of the Great Dividing Range in NSW, south from the Guyra and Inverell districts. It is widely distributed throughout the tablelands, western slopes and western plains. In the Hunter Valley, the species is only known to occur in the Wybong district where several sub-populations have been recorded (Peake 2006). The records of this species within the Study Area add to the small number of records for this species in the Hunter Valley. These current records add to a previous record of the species from the Study Area, and are likely to be approaching the eastern limit of this species in the Hunter Valley.

52. *Isotropis foliosa*

Isotropis foliosa is a subshrub to 60 cm high, flowering in spring (Porteners 2002). *Isotropis foliosa* occurs in NSW and Queensland. In NSW, it occurs north of Denman to the Queensland border. It mainly occurs in the NSW bioregions (Thackway & Creswell, 1995) of Nandewar and Sydney Basin, with other records from New England Tableland, NSW North Coast and the Brigalow Belt South bioregions (DEC 2006bu). The species often grows in sclerophyll forests on skeletal sites (Porteners 2002) and in the Hunter Valley the species has been recorded on sandy and alluvial soils on ridgelines and hillslopes (Peake et al. in prep). The species occurs chiefly on the Slopes, north of Denman (Porteners 2002). The distribution of this species extends to south-east Queensland, however only a small number of populations have been recorded (Peake 2006). In the Hunter Valley, *Isotropis foliosa* is known to occur between Appletree Flat (within Wollemi National Park), Dingo Creek (within Wollemi National Park) and Scone (Peake 2006). The Hunter Valley appears to be a stronghold for the species however, there are relatively few populations in total and most populations across NSW comprise very few individuals (Peake et al. in prep). *Isotropis foliosa* populations are small, with at least six populations only recording a few plants, three populations with one to several hundred plants, and one population on private property with a thousand to several thousand plants. The total number of individuals is estimated to be 1500-6500, although not all of these may be mature. *Isotropis foliosa* is found in Wollemi National Park, with a population of about a hundred plants just within the boundary of the Park.

a) Whether the life cycle of the species is likely to be disrupted such that a local viable population of the species is likely to be placed at risk of extinction.

Isotropis foliosa was not identified within the Study Area, despite extensive, seasonal surveys. It is considered that a local viable population of this species is not likely to be present within the Study Area.

The Anvil Hill Project is unlikely to disrupt a local viable population of the species, such that the species is likely to be placed at risk of extinction.

b) In relation to the regional distribution of the habitat of the threatened species, whether a significant area of known habitat is to be modified or removed, or isolated from currently interconnecting or proximate areas.

Isotropis foliosa was not identified within the Study Area, despite extensive, seasonal surveys. The Study Area does not contain a significant area of known habitat for this species, and it is considered unlikely that this species is present within the Study Area.

A significant area of known habitat for this species will not be modified or removed, or isolated from currently interconnecting or proximate areas as a result of the Anvil Hill Project.

There are only a small number of records of this species from the Hunter Valley. These records occur near the Denman, Scone and Broke regions, however represent only five records all together. One of the Denman records is near to the Study Area.

c) Whether the species, or its habitat, are adequately represented in conservation reserves (or other similar protected areas) in the region.

Isotropis foliosa has been recorded as being present within a conservation reserve(s) within the region (Briggs and Leigh 1995), however there are no records stating which reserve(s) the species occurs in. Given the lack of records available, in addition to the extensive disturbance of potential habitat for this species as a result of mining and agricultural practices within the region, it is not considered that this species is adequately represented within conservation reserves.

d) Whether the species is at the limit of its known distribution.

Isotropis foliosa occurs in NSW and Queensland. In NSW, it occurs north of Denman to the Queensland border. It mainly occurs in the NSW bioregions (Thackway & Creswell, 1995) of Nandewar and Sydney Basin, with other records from New England Tableland, NSW North Coast and the Brigalow Belt South bioregions (DEC 2006bu). The distribution of this species extends to south-east Queensland (Peake 2006). In the Hunter Valley, *Isotropis foliosa* is known to occur between Appletree Flat (within Wollemi National Park), Dingo Creek (within Wollemi National Park) and Scone (Peake 2006). A record of this species from the Study Area would add to the very small number of existing records for this species in the Hunter Valley, however it would not be a distributional limit of this species.

53. *Kennedia retrorsa*

Kennedia retrorsa is a prostrate or climbing herb, with stems growing to 2 metres long, and flowering in spring (Gardner & James 2002). This species is believed to be restricted to the Mount Dangar area and the adjacent Goulburn River catchment, within the Muswellbrook and adjacent Merriwa local government areas. Sites occur within Goulburn River and Wollemi National Parks and nearby private land (DEC 2006bt). Found in a variety of habitats from mountainsides to riparian zones, from sheltered forest to steep, exposed rocky ridgelines (DEC 2006bt). This species is likely to be fire sensitive, but some individuals may survive in certain protected situations (DEC 2006bt).

a) Whether the life cycle of the species is likely to be disrupted such that a local viable population of the species is likely to be placed at risk of extinction.

Kennedia retrorsa was not identified within the Study Area, despite extensive, seasonal surveys. It is considered that a local viable population of this species is not likely to be present within the Study Area.

The Anvil Hill Project is unlikely to disrupt a local viable population of the species, such that the species is likely to be placed at risk of extinction.

b) ***In relation to the regional distribution of the habitat of the threatened species, whether a significant area of known habitat is to be modified or removed, or isolated from currently interconnecting or proximate areas.***

Kennedia retrorsa was not identified within the Study Area, despite extensive, seasonal surveys. The Study Area does not contain a significant area of known habitat for this species, and it is considered unlikely that this species is present within the Study Area.

A significant area of known habitat for this species will not be modified or removed, or isolated from currently interconnecting or proximate areas as a result of the Anvil Hill Project.

There are only a very small number of records of this species from New South Wales, with the majority being from two clusters of records in Yengo, Wollemi and Goulburn River National Parks. There are additional single records of this species north of Gungal, as well as from northern Sydney.

c) ***Whether the species, or its habitat, are adequately represented in conservation reserves (or other similar protected areas) in the region.***

There are nine records of *Kennedia retrorsa* documented for Goulburn River National Park, and three records of this species within Wollemi National Park (DEC 2006bt). It is considered that there may be over 1000 plants of this species occurring within Wollemi National Park, however less than 1000 are estimated for Goulburn River National Park (Briggs and Leigh 1995). Given this information, *Kennedia retrorsa* is well protected within conservation reserves.

d) ***Whether the species is at the limit of its known distribution.***

This species is believed to be restricted to the Mount Dangar area and the adjacent Goulburn River catchment, within the Muswellbrook and adjacent Merriwa local government areas. Sites occur within Goulburn River and Wollemi National Parks and nearby private land (DEC 2006bt). A record of this species from the Study Area would represent an extension to the known distribution of this species.

54. *Lasiopetalum longistamineum*

Lasiopetalum longistamineum is a spreading shrub to 1.5 metres high, flowering in spring (Harden 2000). The species typically grows in rich alluvial deposits and is only known to occur within the Central West Slopes botanical subdivision (Harden 2000). It has been recorded from the Mt Dangar - Gungal area within Merriwa and Muswellbrook Local Government Areas. A couple of sites are recorded within Goulburn River National Park (DEC 2006c).

a) ***Whether the life cycle of the species is likely to be disrupted such that a local viable population of the species is likely to be placed at risk of extinction.***

Lasiopetalum longistamineum was recorded within the Study Area on five occasions. From an analysis of known records of this species within the Study Area, the Anvil Hill Project will result in the overall loss of 58.2% of potential habitat (vegetation communities where this species was recorded) for this species.

The Study Area provides known habitat for this species, and the number of records for this species suggests that the Study Area provides habitat for a population of this species. All records for this species were from the Proposed Offset Areas.

The Anvil Hill Project will require the removal of a large area of vegetation within the Proposed Disturbance Area. As this species was only recorded within the Proposed Offset Areas, no known plants will be impacted by the Anvil Hill Project. There is the potential that this species occurs in other parts of the Study Area, however the majority of these are located within the Proposed Offset Areas. If this species was present within the Proposed Disturbance Area, it is likely to be in only very small numbers. It is unlikely that the Anvil Hill Project will disrupt the life cycle of this species, such that a local viable population of this species is likely to be placed at risk of extinction.

b) In relation to the regional distribution of the habitat of the threatened species, whether a significant area of known habitat is to be modified or removed, or isolated from currently interconnecting or proximate areas.

Known records of this species from New South Wales (and the Hunter Valley) are concentrated as a small number of records from the large vegetation remnant bordered by Manobalai, Wybong, Mt Dangar (in Goulburn River National Park) and Wappinguy. Outside of this area, there are no further known records of this species.

As this species was only recorded from the Proposed Offset Areas, the potential impact from the Anvil Hill Project will be minimal. While there is potential habitat for this species within the Proposed Disturbance Area, this habitat is limited to small areas of sandstone outcrops. These areas are not likely to be impacted by the Anvil Hill Project. If this species was present within the Proposed Disturbance Area, it is expected that these would be very small numbers. While the Anvil Hill Project is likely to cause some isolation of known habitat, the reliance of this species on sandstone outcrops means that populations are naturally fragmented and partially isolated. It is unlikely that the Anvil Hill Project will cause a significant area of known habitat to be modified or removed, or isolated from currently interconnecting or proximate areas of known habitat for this species.

c) Whether the species, or its habitat, are adequately represented in conservation reserves (or other similar protected areas) in the region.

There are three records of *Lasiopetalum longistamineum* documented for Goulburn River National Park (DEC 2006c). Given that this species has only one record within a conservation reserve within the region, it is unlikely that this species is adequately protected.

d) Whether the species is at the limit of its known distribution.

This species has been recorded from the Mt Dangar - Gungal area within Merriwa and Muswellbrook Local Government Areas. A couple of sites are recorded within Goulburn River National Park (DEC 2006c). The record of this species from the Study Area forms part of the known cluster of records for this species in the Hunter Valley. This record is not at the distributional limit of this species.

55. *Philotheca ericifolia*

Philotheca ericifolia is a many-branched, wide spreading shrub 1-2 metres high flowering in spring (Weston & Harden 2002). This species is known only from the upper Hunter Valley and Pilliga to Peak Hill districts of NSW. The records are scattered over a range of over 400 kilometres between West Wyalong and the Pilliga Scrub. Site localities include Pilliga East State Forest, Goonoo State Forest, Hervey Range, Wingen Maid Nature Reserve, Toongi, Denman, Rylestone district and Kandos Weir (DEC 2006bw). In the Hunter Valley the species is known from Wingen Maid Nature Reserve, near Scone (Hill et al. 2001, Hosking & Bruhl 2000). It grows chiefly in dry sclerophyll forest and heath on damp sandy flats and gullies. It has been collected from a variety of habitats including heath, open woodland, dry sandy creek beds, and rocky ridge and cliff tops (DEC 2006bw). It is noted as being a "moisture-loving plant", with plants common on the sides of a particular spur of the Hervey Ranges where soakage from the high background provides sufficient moisture for the plants. This species has also been recorded growing in a recently burnt site (wildfire) and within a regeneration zone resulting from clearing (DEC 2006bw). Populations comprise from 3-12 adult plants to approx. 200 plants (mostly seedlings in one population). Populations in Pilliga State Forest consist of hundreds or thousands of individuals. A very large population occurs in Lincoln State Forest near Gilgandra (DEC 2006bw).

a) Whether the life cycle of the species is likely to be disrupted such that a local viable population of the species is likely to be placed at risk of extinction.

Philotheca ericifolia was not identified within the Study Area, despite extensive, seasonal surveys. It is considered that a local viable population of this species is not likely to be present within the Study Area.

The Anvil Hill Project is unlikely to disrupt a local viable population of the species, such that the species is likely to be placed at risk of extinction.

b) In relation to the regional distribution of the habitat of the threatened species, whether a significant area of known habitat is to be modified or removed, or isolated from currently interconnecting or proximate areas.

Philotheca ericifolia was not identified within the Study Area, despite extensive, seasonal surveys. The Study Area does not contain a significant area of known habitat for this species, and it is considered unlikely that this species is present within the Study Area.

A significant area of known habitat for this species will not be modified or removed, or isolated from currently interconnecting or proximate areas as a result of the Anvil Hill Project.

The majority of records of this species come from Goonoo and Pilliga East State Forests. In the Hunter Valley region, this species is known from a small number of records only, these being from the Sandy Hollow and Wingen areas.

c) Whether the species, or its habitat, are adequately represented in conservation reserves (or other similar protected areas) in the region.

There is one record of *Philotheca ericifolia* documented for the nine conservation reserves identified within the region surrounding the Study Area. This record is from Wingen Maid Nature Reserve. As such, it is unlikely that this species is adequately represented in conservation reserves within the region.

d) Whether the species is at the limit of its known distribution.

This species is known only from the upper Hunter Valley and Pilliga to Peak Hill districts of NSW. The records are scattered over a range of over 400 kilometres between West Wyalong and the Pilliga Scrub. Site localities include Pilliga East State Forest, Goonoo State Forest, Hervey Range, Wingen Maid Nature Reserve, Toongi, Denman, Rylestone district and Kandos Weir (DEC 2006bw). In the Hunter Valley the species is known from Wingen Maid Nature Reserve, near Scone (Hill et al. 2001, Hosking & Bruhl 2000). A record of this species from the Study Area would not be at the distributional limit of this species.

56. *Pomaderris bodalla*

Pomaderris bodalla is a shrub 2-4 metres high. This species is endemic to NSW and is currently known to occur on the south coast between Bodalla and Merimbula, and in the upper Hunter Valley near Muswellbrook. On the south coast, it occurs in moist open forest along sheltered gullies or along stream banks. In the upper Hunter valley, it occurs in open forest or woodland on open slopes (NSW Scientific Committee 2005d). There are ten populations of *Pomaderris bodalla* currently known, and a further two imprecisely described locations from which the species was collected approximately 40 years ago. The majority of populations are small with seven of the populations having estimates of less than a hundred plants each. All populations have locally restricted distributions (NSW Scientific Committee 2005d). The largest known population is in Wollemi National Park and is unlikely to include more than one thousand plants. *Pomaderris bodalla* is in the conservation reserves of Kooraban National Park on the south coast, and in Wollemi National Park and Wingen Maid Nature Reserve in the north of its range. Other populations on the south coast are located in State Forests and on private land (NSW Scientific Committee 2005d).

a) *Whether the life cycle of the species is likely to be disrupted such that a local viable population of the species is likely to be placed at risk of extinction.*

Pomaderris bodalla was not identified within the Study Area, despite extensive, seasonal surveys. It is considered that a local viable population of this species is not likely to be present within the Study Area.

The Anvil Hill Project is unlikely to disrupt a local viable population of the species, such that the species is likely to be placed at risk of extinction.

b) *In relation to the regional distribution of the habitat of the threatened species, whether a significant area of known habitat is to be modified or removed, or isolated from currently interconnecting or proximate areas.*

Pomaderris bodalla was not identified within the Study Area, despite extensive, seasonal surveys. The Study Area does not contain a significant area of known habitat for this species, and it is considered unlikely that this species is present within the Study Area.

A significant area of known habitat for this species will not be modified or removed, or isolated from currently interconnecting or proximate areas as a result of the Anvil Hill Project.

The majority of records of this species are from the south east corner of New South Wales, however there is a single record nearby from within Wollemi National Park.

c) *Whether the species, or its habitat, are adequately represented in conservation reserves (or other similar protected areas) in the region.*

There is one record of *Pomaderris bodalla* documented as occurring within Wollemi National Park (NPWS Wildlife Atlas Database 2006), and a further record in Wingen Maid Nature Reserve (Hill et al. 2001). Given that all the records of *Pomaderris bodalla* are from conservation reserves within the region, this species is adequately protected.

d) *Whether the species is at the limit of its known distribution.*

This species is endemic to NSW and is currently known to occur on the south coast between Bodalla and Merimbula, and in the upper Hunter valley near Muswellbrook. A record of this species from the Study Area would represent the third record of this species from the Hunter Valley, and would be close to its northern distributional limit at Scone.

57. *Pomaderris queenslandica*

This species is a medium-sized shrub 2-3 metres high, flowering during spring and summer (DEC 2006f). It has a widely scattered distribution, but is not common in north-east NSW and in Queensland (DEC 2006f). It is only known from a few locations on the New England Tablelands and North West Slopes, including near Torrington and Coolatai, and also from several locations on the NSW north coast (DEC 2006f). Within NSW, it occurs on the slopes north from the Peak Hill district and also in the Gloucester district (Harden 2000). In the Hunter Valley, the species has been recorded at Myambat Military Area (Fallding et al. 1999), on the slopes of the Glen Range in Towarri NP (Hill et al. 2001), in the Wybong uplands at Anvil Hill and Limb of Addy Hill and also in Manobalai NR (Bell 2001). The species typically occurs in open forest (Harden 2000), especially in sheltered locations (Fallding et al. 1999). It is also found in moist eucalypt forest or sheltered woodlands with a shrubby understorey, and occasionally along creeks (DEC 2006f).

a) Whether the life cycle of the species is likely to be disrupted such that a local viable population of the species is likely to be placed at risk of extinction.

Pomaderris queenslandica was recorded within the Study Area on 14 occasions. From an analysis of known records of this species within the Study Area, the Anvil Hill Project will result in the overall loss of 57.3% of potential habitat (vegetation communities where this species was recorded) for this species.

The Study Area provides known habitat for this species, and its populations. The location of known habitat suggests that further records of this species could be found in other parts of the Study Area, however most of these are likely to be in the Proposed Offset Areas, due to the presence of sandstone outcrops and footslopes.

There is one record of this species within the Proposed Disturbance Area, and this habitat will be removed as a result of the Anvil Hill Project. The remaining records of this species are from the Proposed Offset Areas, thus impact from the Anvil Hill Project will be minimal. The majority of habitat for this species occurs close to sandstone footslopes, and the majority of this type of habitat is within the Proposed Offset Areas.

The Anvil Hill Project will require the removal of a large area of vegetation within the Proposed Disturbance Area. As this species was recorded from the Proposed Disturbance Area, this habitat will be lost. It is not considered that this loss will represent a significant proportion of the known population of this species within the Study Area. It is unlikely that the Anvil Hill Project will disrupt the life cycle of this species, such that a local viable population of this species is likely to be placed at risk of extinction.

b) In relation to the regional distribution of the habitat of the threatened species, whether a significant area of known habitat is to be modified or removed, or isolated from currently interconnecting or proximate areas.

There are a small number of records of this species within the Hunter Valley. Most of these records are from an area to the west of Muswellbrook, where at least ten records exist.

As the majority of records (14) of this species are from the Proposed Offset Areas, the potential impact from the Anvil Hill Project will not be significant. It is considered that the loss of the single record of this species within the Proposed Disturbance Area does not represent a significant proportion of the known population of this species within the Study Area. It is unlikely that the Anvil Hill Project will cause a significant area of known habitat to be modified or removed, or isolated from currently interconnecting or proximate areas of known habitat for this species.

c) Whether the species, or its habitat, are adequately represented in conservation reserves (or other similar protected areas) in the region.

One record of *Pomaderris queenslandica* is documented as occurring within Manobalai Nature Reserve and two records for Towarri National Park (DEC 2006f). Given the low number of recorded occurrences of this species within conservation reserves of the region, it is unlikely that this species is adequately protected.

d) Whether the species is at the limit of its known distribution.

This species is only known from a few locations on the New England Tablelands and North West Slopes, including near Torrington and Coolatai, and also from several locations on the NSW north coast (DEC 2006f). In the Hunter Valley, the species has been recorded at Myambat Military Area (Fallding et al. 1999), on the slopes of the Glen Range in Towarri NP (Hill et al. 2001), in the Wybong uplands at Anvil Hill and Limb of Addy Hill and also in Manobalai NR (Bell 2001). The record of this species from the Study Area adds to a known previous record from the Study Area, however does not represent a distributional limit of this species.

58. *Pomaderris reperta*

A shrub growing 1-3 metres high with young stems densely villous (Walsh & Coates 1997). One record has shown that *P. reperta* flowers in October (Walsh & Coates 1997). This species has been recorded from a small number of sites along a single ridgeline near Denman in the upper Hunter Valley (Muswellbrook local government area) (DEC 2006g). It has been recorded from the Myambat Military Area (Fallding et al. 1999) and also west of Denman (Bell 2001). The species typically occurs in dry sclerophyll woodland (Harden 2000) on rocky slopes and sandy soils (Fallding et al. 2001) derived from Hawkesbury Sandstones (Walsh & Coates 1997). This species is primarily associated with the canopy species narrow-leaved ironbark (*Eucalyptus crebra*), Blakely's red gum (*Eucalyptus blakelyi*) (Walsh & Coates 1997), and grey box (*Eucalyptus molucanna*) (Fallding et al. 1999). This species has not previously been recorded within any formal conservation reserves however, approximately 20-40 plants have been recorded within the Myambat Military Area which is managed by the Commonwealth Department of Defence (Fallding et al. 1999).

a) Whether the life cycle of the species is likely to be disrupted such that a local viable population of the species is likely to be placed at risk of extinction.

Pomaderris reperta was recorded within the Study Area on 16 occasions. From an analysis of known records of this species within the Study Area, the Anvil Hill Project will result in the overall loss of 58.2% of potential habitat (vegetation communities where this species was recorded) for this species.

The Study Area provides known habitat for this species, as well as several sub-populations. The location of known habitat for this species suggests that further records of this species could be found in other parts of the Study Area, however most of these are likely to be in the Proposed Offset Areas, due to the presence of sandstone outcrops and vegetation of the nearby footslopes.

There are no records of this species within the Proposed Disturbance Area, however potential habitat exists around the footslopes of sandstone outcrops. In addition to this, potential habitat for this species exists in areas of dense vegetation removed from the footslopes in the south east of the Proposed Disturbance Area. The majority of habitat for this species occurs close to sandstone footslopes, and the majority of this habitat is within the Proposed Offset Areas.

The Anvil Hill Project will require the removal of a large area of vegetation within the Proposed Disturbance Area. As this species was not recorded from the Proposed Disturbance Area, the potential impact of the Anvil Hill Project will be minimal. It is considered that the loss of potential habitat within the Study Area is unlikely to disrupt the life cycle of this species, such that a local viable population of this species is likely to be placed at risk of extinction.

b) In relation to the regional distribution of the habitat of the threatened species, whether a significant area of known habitat is to be modified or removed, or isolated from currently interconnecting or proximate areas.

There are very few records of this species within New South Wales, with the majority of these being from the Hunter Valley. One of these records is from Yengo National Park, however the remaining records from the Hunter Valley are from the Denman area. There is a previous record of this species from the Study Area.

As all of the records of this species are from the Proposed Offset Areas, the potential impact from the Anvil Hill Project will not be significant. It is considered that the loss of the potential habitat within the Proposed Disturbance Area will not represent a significant proportion of the potential (or known) habitat of this species within the Study Area. It is unlikely that the Anvil Hill Project will cause a significant area of known habitat to be modified or removed, or isolated from currently interconnecting or proximate areas of known habitat for this species.

c) Whether the species, or its habitat, are adequately represented in conservation reserves (or other similar protected areas) in the region.

There are no records of *Pomaderris reperta* documented for any of the nine conservation reserves identified within the region surrounding the Study Area. As such, it is unlikely that this species is adequately represented in conservation reserves within the region.

d) Whether the species is at the limit of its known distribution.

This species has been recorded from a small number of sites along a single ridgeline near Denman in the upper Hunter Valley (Muswellbrook local government area) (DEC 2006g). It has been recorded from the Myambat Military Area (Fallding et al. 1999) and also west of Denman (Bell 2001). The record of this species from the Study Area adds to the small number of records of this species, and is likely to represent a small northerly extension to the known distribution of this species.

59. *Prostanthera cineolifera*

Prostanthera cineolifera is an erect shrub, 1-4 metres high and strongly aromatic (DEC 2006bx). This species is restricted to only a few localities near Walcha, Scone and St Albans (DEC 2006bx). It has been recorded growing in open woodlands on exposed sandstone ridges, usually in association with shallow or skeletal sands. The fire response of this species is unknown, but other *Prostanthera* species are fire sensitive.

a) ***Whether the life cycle of the species is likely to be disrupted such that a local viable population of the species is likely to be placed at risk of extinction.***

Prostanthera cineolifera was not identified within the Study Area, despite extensive, seasonal surveys. It is considered that a local viable population of this species is not likely to be present within the Study Area.

The Anvil Hill Project is unlikely to disrupt a local viable population of the species, such that the species is likely to be placed at risk of extinction.

b) ***In relation to the regional distribution of the habitat of the threatened species, whether a significant area of known habitat is to be modified or removed, or isolated from currently interconnecting or proximate areas.***

Prostanthera cineolifera was not identified within the Study Area, despite extensive, seasonal surveys. The Study Area does not contain a significant area of known habitat for this species, and it is considered unlikely that this species is present within the Study Area.

A significant area of known habitat for this species will not be modified or removed, or isolated from currently interconnecting or proximate areas as a result of the Anvil Hill Project.

There are only three records of this species within the Hunter Valley. These records come from an area to the west of Scone, one near North Rothbury and the final record from Pokolbin State Forest. The remaining records of this species from New South Wales come from the southern section of Yengo National Park, and from Apsley Falls, near Oxley Wild Rivers National Park.

c) ***Whether the species, or its habitat, are adequately represented in conservation reserves (or other similar protected areas) in the region.***

There are no records of *Pomaderris cineolifera* documented for any of the nine conservation reserves identified within the region surrounding the Study Area. As such, it is unlikely that this species is adequately represented in conservation reserves within the region.

d) ***Whether the species is at the limit of its known distribution.***

This species is restricted to only a few localities near Walcha, Scone and St Albans (DEC 2006bx). A record of this species from the Study Area is likely to represent the western-most record of this species from New South Wales.

60. *Prostanthera cryptandroides*

Prostanthera cryptandroides is a low-spreading shrub with a distinctive, pleasant aroma commonly growing 0.5 - 1 metre tall and up to 1 metre wide (DEC 2006by). Flowers occur from September to May. This species is recorded from restricted areas, but over a fairly broad range from the Lithgow and Sandy Hollow Districts into the Border Rivers/Gwydir Catchment and up into Queensland (DEC 2006by). It has been recorded from Wollemi National Park and is likely to occur within Goulburn River National Park. At Glen Davis, this species occurs in open forest dominated by red ironbark (*Eucalyptus fibrosa*). In the Denman-Gungal and Widden-Baerami Valley areas, this species occurs on rocky ridgelines on Narrabeen Group Sandstones in association with a range of communities (DEC 2006by).

a) ***Whether the life cycle of the species is likely to be disrupted such that a local viable population of the species is likely to be placed at risk of extinction.***

Prostanthera cryptandroides was not identified within the Study Area, despite extensive, seasonal surveys. It is considered that a local viable population of this species is not likely to be present within the Study Area.

The Anvil Hill Project is unlikely to disrupt a local viable population of the species, such that the species is likely to be placed at risk of extinction.

b) ***In relation to the regional distribution of the habitat of the threatened species, whether a significant area of known habitat is to be modified or removed, or isolated from currently interconnecting or proximate areas.***

Prostanthera cryptandroides was not identified within the Study Area, despite extensive, seasonal surveys. The Study Area does not contain a significant area of known habitat for this species, and it is considered unlikely that this species is present within the Study Area.

A significant area of known habitat for this species will not be modified or removed, or isolated from currently interconnecting or proximate areas as a result of the Anvil Hill Project.

Records of this species within New South Wales come from two main clumps, one being from the Glen Davis area on the western edge of Wollemi National Park, and the other from near Denman. Here there are records from the northern edge of Wollemi National Park, and others from the Myambat Military Area. A previous record of this species exists from the Study Area. There are further single isolated records of this species from Parkes and Bald Rock National Park on the Queensland border.

c) ***Whether the species, or its habitat, are adequately represented in conservation reserves (or other similar protected areas) in the region.***

There are eight records of *Prostanthera cryptandroides* documented for Wollemi National Park (DEC 2006by). This species is also considered likely to occur in Goulburn River National Park (NPWS Threatened Species Profile 2000). This species is presumed extinct in some areas of the region, however is present in the south where it is found in Wollemi National Park (Briggs and Leigh 1995). Given the limited number of records of *Prostanthera cryptandroides* within conservation reserves, it is unlikely that this species is adequately reserved within the region.

d) ***Whether the species is at the limit of its known distribution.***

This species is recorded from restricted areas, but over a fairly broad range from the Lithgow and Sandy Hollow Districts into the Border Rivers/Gwydir Catchment and up into Queensland (DEC 2006by). It has been recorded from Wollemi National Park and is likely to occur within Goulburn River National Park. A record of this species from the Study Area would not be at the distributional limit of this species.

61. *Prostanthera discolor*

Prostanthera discolor is an open, erect shrub with a strong aroma and hairy branches, commonly growing 0.6-3 metres high (DEC 2006bz). Flowering usually occurs September to October. This species is restricted to only a few localities from Bylong to the Baerami Valley within the Rylstone and Muswellbrook local government areas (DEC 2006bz). It grows in dry sclerophyll forest in the side gullies of main creeklines, often on rocky or well-drained alluvial substrates.

a) Whether the life cycle of the species is likely to be disrupted such that a local viable population of the species is likely to be placed at risk of extinction.

Prostanthera discolor was not identified within the Study Area, despite extensive, seasonal surveys. It is considered that a local viable population of this species is not likely to be present within the Study Area.

The Anvil Hill Project is unlikely to disrupt a local viable population of the species, such that the species is likely to be placed at risk of extinction.

b) In relation to the regional distribution of the habitat of the threatened species, whether a significant area of known habitat is to be modified or removed, or isolated from currently interconnecting or proximate areas.

Prostanthera discolor was not identified within the Study Area, despite extensive, seasonal surveys. The Study Area does not contain a significant area of known habitat for this species, and it is considered unlikely that this species is present within the Study Area.

A significant area of known habitat for this species will not be modified or removed, or isolated from currently interconnecting or proximate areas as a result of the Anvil Hill Project.

The only known records of this species come from Goulburn River and Wollemi National Parks.

c) Whether the species, or its habitat, are adequately represented in conservation reserves (or other similar protected areas) in the region.

There are seven records of this species occurring within Wollemi National Park (DEC 2006bz). A population of this species has also been recorded within Goulburn River National Park (Briggs and Leigh 1995). It is likely that this species is adequately protected within conservation reserves in the region.

d) Whether the species is at the limit of its known distribution.

This species is restricted to only a few localities from Bylong to the Baerami Valley within the Rylstone and Muswellbrook local government areas (DEC 2006bz). A record of this species from the Study Area would represent the only known record of this species outside of Wollemi and Goulburn River National Parks. Such a record would also represent a northerly extension to the known range of this species.

62. Austral toadflax - *Thesium australe*

Austral toadflax (*Thesium australe*) is a small, straggling herb to 40 cm tall (DEC 2006ca), flowering in spring. This species is often hidden amongst grasses and herbs and is found in very small populations scattered across eastern NSW, along the coast, and from the Northern to Southern Tablelands. It is also found in Tasmania and Queensland and in eastern Asia (DEC 2006ca). Recorded habitat for this species is either grassland or grassy woodland, and it is often found in damp sites in association with kangaroo grass (*Themeda australis*).

a) Whether the life cycle of the species is likely to be disrupted such that a local viable population of the species is likely to be placed at risk of extinction.

Austral toadflax (*Thesium australe*) was not identified within the Study Area, despite extensive, seasonal surveys. It is considered that a local viable population of this species is not likely to be present within the Study Area.

The Anvil Hill Project is unlikely to disrupt a local viable population of the species, such that the species is likely to be placed at risk of extinction.

b) In relation to the regional distribution of the habitat of the threatened species, whether a significant area of known habitat is to be modified or removed, or isolated from currently interconnecting or proximate areas.

Austral toadflax (*Thesium australe*) was not identified within the Study Area, despite extensive, seasonal surveys. The Study Area does not contain a significant area of known habitat for this species, and it is considered unlikely that this species is present within the Study Area.

A significant area of known habitat for this species will not be modified or removed, or isolated from currently interconnecting or proximate areas as a result of the Anvil Hill Project.

Records of this species in New South Wales are mainly from the north east and south east corners of the state. Within the Hunter Valley region, a small number of records exist from the Cassilis and Blackville areas.

c) Whether the species, or its habitat, are adequately represented in conservation reserves (or other similar protected areas) in the region.

There are no records of austral toadflax *(Thesium australe*) documented for any of the nine conservation reserves identified within the region surrounding the Study Area. As such, it is unlikely that this species is adequately represented in conservation reserves within the region.

d) Whether the species is at the limit of its known distribution.

This species is found in very small populations scattered across eastern NSW, along the coast, and from the Northern to Southern Tablelands. It is also found in Tasmania and Queensland and in eastern Asia (DEC 2006ca). A record of this species from the Study Area would represent one of the few records from the Hunter Valley, and would be the eastern-most record of this species in the Hunter Valley, however not in New South Wales.

Endangered Populations

1. Weeping myall - *Acacia pendula* population

The endangered population of weeping myall (*Acacia pendula*) consists of a disjunct population of fewer than 1000 individuals that occurs in the Hunter Valley at the eastern distributional limit of the species' range (DEC 2006cb). The trees are erect or spreading 5-13 metres high with a pendulous habit. Their bark is hard, fissured, dark grey to black (DEC 2006cb). The species occurs on the western slopes, western plains and far western plains of NSW, and south into Victoria and north into Queensland. This Hunter population is known to occur naturally as far east as Warkworth, and extends northwest to Muswellbrook and to the west of Muswellbrook at Wybong (DEC 2006cb). Examples of this population recorded to date at six locations comprise Jerrys Plains, Edderton, Wybong, Appletree Creek, Warkworth and Appletree Flat. These are within the local government areas of Muswellbrook, Singleton and Upper Hunter (DEC 2006cb). Within the Hunter catchment the species typically occurs on heavy soils, sometimes on the margins of small floodplains, but also in more undulating locations. It is not known to occur within any conservation areas (DEC 2006cb).

a) Whether the lifecycle of the species that constitutes the endangered population is likely to be disrupted such the viability of the population is likely to be significantly compromised.

The endangered population of weeping myall (*Acacia pendula*) was recorded on two occasions within the Study Area, where small clusters of individuals comprise examples of this endangered population. One record of this endangered population occurs within the Proposed Disturbance Area, in the centre of the proposed rail loop, and the other occurs within the Proposed Disturbance Area.

The Anvil Hill Project is unlikely to disrupt an example of this endangered population, such that the species is likely to be placed at risk of extinction.

b) In relation to the regional distribution of the habitat of the endangered population, whether a significant area of known habitat is to be modified or removed, or isolated from currently interconnecting or proximate areas.

This endangered population is only known from six locations within the Hunter Valley, these being Jerrys Plains, Edderton, Wybong, Appletree Creek, Warkworth and Appletree Flat.

The endangered population of this species already exists within a highly fragmented landscape. While the Anvil Hill Project will require the removal of a large amount of vegetation within the Proposed Disturbance Area, this will not increase the existing fragmentation or isolation of this endangered population.

c) Whether the endangered population, or its habitat, are adequately represented in conservation reserves (or other similar protected areas) in the region.

This species is not known to occur in conservation reserves within the region (DEC 2006cb), therefore it is inadequately protected within conservation reserves within the region.

d) Whether any threatened species, population or ecological community is at the limit of its known distribution.

The endangered population of weeping myall (*Acacia pendula*) consists of a disjunct population of fewer than 1000 individuals that occurs in the Hunter Valley at the eastern distributional limit of the species' range (DEC 2006cb). This Hunter population is known to occur naturally as far east as Warkworth, and extends northwest to Muswellbrook and to the west of Muswellbrook at Wybong (DEC 2006cb). Examples of this population have only recorded to date at six locations comprising Jerrys Plains, Edderton, Wybong, Appletree Creek, Warkworth and Appletree Flat. The record of this endangered population within the Study Area is likely to represent an additional location for this population within the Hunter Valley, however it does not occur at a distributional limit of this population.

2. River red gum - *Eucalyptus camaldulensis* population

The population of river red gum (*Eucalyptus camaldulensis*) in the Hunter Valley is unique in NSW, being the only one to occur in a coastal catchment. It is disjunct and at the limit of range of the species, it may be genetically distinct, and is of conservation significance as the community dominant in distinct riparian and floodplain vegetation types (DEC 2006cc). The Hunter Valley population occurs from the west at Bylong, south of Merriwa, to the east at Hinton, on the bank of the Hunter River, in the Port Stephens local government area. It has been recorded in the local government areas of Lithgow, Maitland, Mid-Western Regional, Muswellbrook, Port Stephens, Singleton and Upper Hunter (DEC 2006cc). Currently, 19 stands are known, occupying at most 100 ectares, the largest remnant being 15 - 20 hectares in extent. Smaller remnants contain only one to several trees. The total number of individuals is estimated to be between 600 - 1000 mature or semi mature trees. Most of the occurrences of this endangered population are from private land, and there are no known occurrences in conservation reserves (DEC 2006cc).

a) Whether the lifecycle of the species that constitutes the endangered population is likely to be disrupted such the viability of the population is likely to be significantly compromised.

The river red gum (*Eucalyptus camaldulensis*) endangered population was not identified within the Study Area, despite extensive, seasonal surveys. It is considered that a local viable population of this species is not likely to be present within the Study Area.

The Anvil Hill Project is unlikely to disrupt an example of this endangered population, such that the species is likely to be placed at risk of extinction.

b) In relation to the regional distribution of the habitat of the endangered population, whether a significant area of known habitat is to be modified or removed, or isolated from currently interconnecting or proximate areas.

The river red gum (*Eucalyptus camaldulensis*) endangered population was not identified within the Study Area, despite extensive, seasonal surveys. The Study Area does not contain a significant area of known habitat for this endangered population, and it is considered unlikely that this endangered population is present within the Study Area.

A significant area of known habitat for this endangered population will not be modified or removed, or isolated from currently interconnecting or proximate areas as a result of the Anvil Hill Project.

The Hunter Valley population occurs from the west at Bylong, south of Merriwa, to the east at Hinton, on the bank of the Hunter River near Maitland, in the Port Stephens local government area, and north to Aberdeen.

c) Whether the endangered population, or its habitat, are adequately represented in conservation reserves (or other similar protected areas) in the region.

There are no known occurrences of a river red gum (*Eucalyptus camaldulensis*) endangered population occurring within conservation reserves. As such, it is not adequately protected within conservation reserves in the region.

d) Whether any threatened species, population or ecological community is at the limit of its known distribution.

The population of river red gum (*Eucalyptus camaldulensis*) in the Hunter Valley is disjunct and at the limit of range of the species (DEC 2006cc). The Hunter Valley population occurs from the west at Bylong, south of Merriwa, to the east at Hinton, on the bank of the Hunter River, in the Port Stephens local government area. A record of this endangered population from the Study Area would not, however, be at a distributional limit of this population.

3. Tiger orchid - *Cymbidium canaliculatum population*

Tiger orchid (*Cymbidium canaliculatum*) is an epiphyte with sympodial growth flowering during September to October (Jones 1993a) or November (Weston 1993). The species grows in tree hollows in dry sclerophyll forest or woodland (Weston 1993). Within the Hunter Valley, the species is most commonly found in white box-dominated woodlands at a height of 2-6 metres above ground level (Peake et al. in prep. c). Tiger orchid typically grows on white box (*Eucalyptus albens*), however it has been observed growing on other species such as slaty box (*E. dawsonii*), narrow-leaved ironbark (*E. crebra*), grey box (*E. moluccana*), rough-barked apple (*Angophora floribunda*) and cooba (*Acacia salicina*) (Peake et al. in prep. c). The species is chiefly found in inland districts north from the Hunter Valley and west to New Angledool (Weston 1993). It occurs widely in Queensland, the Northern Territory and in the northern parts of Western Australia (Jones 1993a). Regionally, tiger orchid occurs throughout the Hunter Valley west of Jerrys Plains and Gresford, with an estimated 200 to 500 individuals (Peake et al. in prep. c). This species is not believed to be well represented in conservation areas with an estimated 90% of individuals in the Hunter Valley occurring on private land (Peake et al. in prep. c).

a) Whether the lifecycle of the species that constitutes the endangered population is likely to be disrupted such the viability of the population is likely to be significantly compromised.

Tiger orchid (*Cymbidium canaliculatum*) was recorded within the Study Area on 17 occasions. From an analysis of known records of this species within the Study Area, the Anvil Hill Project will result in the overall loss of 58.6% of potential habitat (vegetation communities where this species was recorded) for this species.

Despite the number of separate records of this species within the Proposed Disturbance Area and the Proposed Offset Areas, it is likely that there would be less than 50 individuals in each area. Those individuals recorded within the Study Area are likely to represent a single population of this species, and it is likely that the sub-population of this species that occurs within the Proposed Disturbance Area would constitute a significant area of known habitat for this species. There is the potential that the Anvil Hill Project may disrupt this endangered population such that the viability of the population may be significantly compromised.

b) In relation to the regional distribution of the habitat of the endangered population, whether a significant area of known habitat is to be modified or removed, or isolated from currently interconnecting or proximate areas.

Regionally, tiger orchid (*Cymbidium canaliculatum*) occurs throughout the Hunter Valley west of Jerrys Plains and Gresford, with an estimated 200 to 500 individuals (Peake et al. in prep. c).

While this species was recorded from both the Proposed Disturbance Area and Proposed Offset Areas, the impact from the loss of the Proposed Disturbance Area is likely to be significant on the local population of this species. This will be due to direct loss of the species, and its habitat, as well as the impacts of isolation of the sub-population remaining in the Proposed Offset Areas. The Anvil Hill Project may cause a significant area of known habitat to be modified or removed, or isolated from currently interconnecting or proximate areas of known habitat for this species.

c) Whether the endangered population, or its habitat, are adequately represented in conservation reserves (or other similar protected areas) in the region.

There are no records of tiger orchid (*Cymbidium canaliculatum*) occurring in any conservation reserves within the region. As such, it is unlikely that this species is adequately protected within conservation reserves within the region.

d) Whether any threatened species, population or ecological community is at the limit of its known distribution.

The species is chiefly found in inland districts north from the Hunter Valley and west to New Angledool (Weston 1993). It occurs widely in Queensland, the Northern Territory and in the northern parts of Western Australia (Jones 1993a). Regionally, tiger orchid (*Cymbidium canaliculatum*) occurs throughout the Hunter Valley west of Jerrys Plains and Gresford, with an estimated 200 to 500 individuals (Peake et al. in prep. c). The population of this species occurring within the Hunter Catchment is the most southerly known distribution for this species. The most southern record of this species is located at Jerrys Plains, about 40 kilometres from the Anvil Hill Study Area. Therefore, the population within the Study Area is not at the species' distributional limit.

Endangered Ecological Community

1. Weeping Myall Woodland

The Hunter Valley Weeping Myall Woodland has a dense to open tree canopy to about 15 metres tall with the most common species being weeping myall (*Acacia pendula*). Other canopy species present may include narrow-leaved ironbark (*Eucalyptus crebra*) cooba (*Acacia salicina*) and trees within the *A. homolophylla – A. melvillei* complex (NSW Scientific Committee 2005a). Shrub species include iamboto (*Psydrax odorata*), sticky hopbush (*Dodonaea viscosa*), wilga (*Geijera parviflora*), native olive (*Notelaea microcarpa* subsp. *microcarpa*) and silver cassia (*Senna zygophylla*) (NSW Scientific Committee 2005a). The groundcover varies from dense to sparse and comprises native grasses and herbs. This community is currently known from parts of the Muswellbrook and Singleton local government areas, but may also occur elsewhere in the Sydney Basin Bioregion (NSW Scientific Committee 2005). The total remaining area of this community is estimated to be less than ten hectares (NSW Scientific Committee 2005a) and the community is not known to occur within any conservation reserves (NSW Scientific Committee 2005a).

a) In relation to the regional distribution of the habitat of the endangered ecological community, whether a significant area of known habitat is to be modified or removed, or isolated from currently interconnecting or proximate areas.

One small example of Weeping Myall Woodland has been identified in the Proposed Disturbance Area, within the proposed rail loop. This vegetation community will be retained in the centre of the rail loop, and will not be disturbed as a result of the Project. Another small example of this EEC has been identified within the Proposed Offset Areas, to the north west along Big Flat Creek.

The Anvil Hill Project is unlikely to disrupt an example of this endangered ecological community, such that the community is likely to be placed at risk of extinction. Rather, both known examples of this EEC within the Study Area will be conserved and protected.

b) Whether the endangered ecological community, or its habitat, are adequately represented in conservation reserves (or other similar protected areas) in the region.

The Weeping Myall Woodland is not currently known to occur in any conservation reserves (NSW Scientific Committee 2005a). As such, this ecological community is not adequately protected within the region.

c) Whether the endangered ecological community is at the limit of its known distribution.

This community is currently known from parts of the Muswellbrook and Singleton local government areas, but may also occur elsewhere in the Sydney Basin Bioregion (NSW Scientific Committee 2005a). Its occurrence in the Study Area is not at its known distributional limit.

Key Threatening Processes

a) Whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process.

There are currently a total of 30 key threatening processes (KTPs) (including those pending finalisation) listed under the *Threatened Species Conservation Act* 1995. Of these, a number have been discounted from this assessment, due to their irrelevance to the Study Area and the Anvil Hill Project. The remaining KTPs are listed below, with a discussion on their relevance to the proposed project, and the likelihood of the Anvil Hill Project causing an increase in the incidence of these processes within the Study Area.

Invasion and establishment of exotic vines and scramblers: A large number of exotic vines and scramblers have become established in New South Wales. Exotic vines and scramblers may act as transformer species, alter the nature of the environment where they become dominant, smother existing vegetation and may suppress regeneration of native species.

It is unlikely that any activities associated with the Anvil Hill Project will cause an increase in the incidence of this KTP within the Study Area, or locality in general. Indeed, it is likely that ecological monitoring of remnant vegetation, and management actions such as weeding and revegetation will reduce the incidence of this KTP in the Study Area.

Invasion and establishment of the cane toad: No cane toads (*Bufo marinus*) were recorded within the Study Area during the detailed seasonal surveys completed for this assessment. The current rate of spread in NSW is approximately 3-4 kilometres per year, but may be punctuated by brief periods of relatively rapid movement in some years (DEC 2005 *in lit.*). Cane toads are likely to cause declines in faunal biodiversity by competing for food with other carnivores, by preying upon small vertebrates and by causing intoxication among larger predators such as goannas (*Varanus* spp.) and raptors. 'The biological effects, including lethal toxic ingestion, caused by cane toads (*Bufo marinus)*' has been listed as a Key Threatening Process under the Commonwealth *Environment Protection Biodiversity Conservation Act* 1999.

While this species is known to be transported among interstate cargo (amongst fresh produce, for example), it is unlikely that any activities associated with the Anvil Hill Project will cause an increase in the unwitting importation of this species into the Study Area.

Invasion of *Lantana camara*: *Lantana camara* has spread rapidly along the east coast of Australia, from southern NSW north to Cape York, and from sea-level up to 600 metres altitude, or exceptionally to 1000 metres. This species readily invades disturbed sites and communities, including edges and canopy breaks in dense forest communities. It typically forms dense thickets, suppressing less competitive native vegetation and seedlings through shading, surface-soil nutrient sequestration, smothering and allelopathy.

It is unlikely that any activities associated with the Anvil Hill Project will cause an increase in the incidence of this KTP within the Study Area, or locality in general. Indeed, it is likely that ecological monitoring of remnant vegetation, and management actions such as weeding and revegetation will reduce the incidence of this KTP in the Study Area.

Alteration of habitat following subsidence due to longwall mining: The principal surface impact of underground coal mining is subsidence (lowering of the surface above areas that are mined), which is frequently associated with cracking of valley floors and creeklines and with subsequent effects on surface and groundwater hydrology. Cracking and subsequent water loss can result in permanent changes to riparian community structure and composition. There are no plans for longwall mining as part of the Anvil Hill Project. No activities associated with the Anvil Hill Project will cause an increase in the incidence of this KTP within the Study Area, or locality in general.

Alteration to the natural flow regimes of rivers, streams, floodplains & wetlands: Alteration to the natural flow regimes of rivers and streams and their floodplains and wetlands is recognised as a major factor contributing to loss of biological diversity and ecological function in aquatic ecosystems, including floodplains. Alterations to natural flow regimes of rivers and streams and their floodplains and wetlands could cause a large number of species, populations or ecological communities that rely on river flows for their short term and long term survival.

The NSW Fisheries Scientific Committee has made a complementary determination to list "Installation and operation of instream structures and other mechanisms that alter natural flow regimes of rivers and streams." as a Key Threatening Process under the *Fisheries Management Act* 1994.

Works within or across a number of creek/drainage lines will be required as part of the Anvil Hill Project and surface water capture by the mine and associated disturbance areas will impact on flow regimes. While these issues will be addressed as part of the surface water impact assessment in the EA, it is likely that these works will constitute this Key Threatening Process.

Bushrock removal: Bushrock removal is the removal of natural surface deposits of rock from rock outcrops or from areas of native vegetation. The rocks may be loose rocks on rock surfaces or on the soil surface, or may have been removed from rock outcrops by excavation or blasting. Bushrock removal removes and/or disturbs habitat of native species, which may find shelter in or under rocks, may use rocks for basking, or which grow in rocky areas.

The Anvil Hill Project will require the removal of bushrock from within the Proposed Disturbance Area, however this will only be done as part of approved mining activities. This excludes this activity from the definition of this KTP. No bushrock will be removed within the Proposed Offset Areass. It is unlikely that any activities associated with the Anvil Hill Project will cause an increase in the incidence of this KTP within the Study Area, or locality in general.

Clearing of native vegetation: Parts of the Study Area have already been impacted by historic clearing for agricultural purposes, selective logging, tracks/roads and mining exploration. Clearing is defined as the destruction of a sufficient proportion of one or more strata (layers) within a stand or stands of native vegetation so as to result in the loss, or long term modification, of the structure, composition and ecological function of stand or stands. Clearing of native vegetation is recognised as a major factor contributing to loss of biological diversity.

Land Clearance is listed as a Key Threatening Process under the Commonwealth's *Environment Protection and Biodiversity Act* 1999.

Clearing within the Proposed Disturbance Area will increase the incidence of this KTP within the Study Area, and locality. While detailed ameliorative measures (such as rehabilitation and progressive revegetation of the open cut area) have been included within the Anvil Hill Project, large amounts of vegetation are required to be cleared within the Proposed Disturbance Area, and this loss is likely to contribute to the loss of habitat within the Study Area and local area in general.

Competition and grazing by the feral European rabbit: Feral rabbits have been recorded across the Study Area, although not in high numbers. This species is likely to occur throughout the locality, and this presence is likely to be impacting on the biodiversity within the Study Area, and locality in general. There is evidence that feral rabbits impact negatively on indigenous species via competition for resources, alteration of the structure and composition of vegetation, and land degradation.

Competition and land degradation by feral rabbits is listed as a Key Threatening Process under the Commonwealth *Environment Protection and Biodiversity Conservation Act* 1999.

It is unlikely that any activities associated with the Anvil Hill Project will cause an increase in the incidence of this KTP within the Study Area, or locality in general. Indeed, it is possible that ecological monitoring and pest management programs may reduce the incidence of this KTP in the Study Area.

Competition and habitat degradation by feral goats: Feral goats have been recorded across the Study Area, although not in high numbers. This species is likely to occur throughout the locality, and this presence is likely to be impacting on the biodiversity within the Study Area, and locality in general.

Feral goats occur in most regions of Australia, and have the ability to cause significant habitat degradation. Removal or destruction of vegetation together with trampling decreases soil stability and contributes to erosion (Henzell 1993; Eldridge 1998). Feral Goat activity can significantly alter the habitat of native fauna and flora, as well as compete with native fauna for food, water and shelter.

'Competition and land degradation by Feral Goats' is currently listed as a key threatening process under the Commonwealth *Environment Protection and Biodiversity Conservation Act* 1999.

It is unlikely that any activities associated with the Anvil Hill Project will cause an increase in the incidence of this KTP within the Study Area, or locality in general. Indeed, it is possible that ecological monitoring and pest management programs may reduce the incidence of this KTP in the Study Area.

Competition from feral honeybees: The introduced honeybee (*Apis mellifera*) is abundant and widely but patchily distributed as a feral species across New South Wales. Feral honeybees occur in colonies, and impact on native species via competition for tree hollows and via competition for floral resources.

It is likely that this species is present within the Study Area. It is unlikely that any activities associated with the Anvil Hill Project will cause an increase in the incidence of this KTP within the Study Area, or locality in general. While these bees are known to readily invade nest boxes (a likely component of the offsets strategy), the nest box monitoring program will ensure any infestations are identified and removed on a regular basis.

Ecological consequences of high frequency fires: High frequency fire is defined as two or more successive fires close enough together in time to interfere with or limit the ability of plants or animals to recruit new individuals into a population, or for plants to build-up a seedbank sufficient in size to maintain the population through the next fire. Sustained high frequency fire will consequently lead to a loss of plant species, a reduction in vegetation structure and a corresponding loss of animal species. While most communities are likely to have some tolerance to two fires at a high frequency (one short inter-fire interval), what must be avoided is a sustained sequence of such closely spaced fires.

The Project includes management requirements to deal with bushfires within, and near to the Study Area. As part of the bushfire management, the Study Area will be managed to exclude bushfire, except potentially in cases where small controlled burns are required for fuel reduction or ecological purposes. Such small controlled burns would not occur frequently. While the Project is likely to increase the potential of bushfire in the Study Area (as a result of the operation of the mine) the site will be actively managed to reduce the risk of such unplanned fires, and will include mechanisms and equipment to fight and control unplanned fires. The Project is unlikely to result in an increase in the frequency of bushfire in the area.

Feral pigs: Although no feral pigs were recorded within the Study Area, there is potential habitat for this species in the Study Area, and locality.

Feral Pigs use a wide range of habitat types, however shows a preference for riparian and swampy habitats, as well as dense vegetation types such as wet sclerophyll forest and forested gullies. They pose a significant threat to native species and ecological communities as a result of direct disturbance to habitat, increased erosion, reduction in water quality, increased weed invasion, fauna predation, competition for food resources and alteration to native vegetation assemblages are all impacts attributed to this species.

'Predation, habitat degradation, competition and disease transmission by Feral Pigs' is currently listed as a key threatening process under the Commonwealth *Environment Protection and Biodiversity Conservation Act* 1999.

It is unlikely that any activities associated with the Anvil Hill Project will cause an increase in the incidence of this KTP within the Study Area, or locality in general. Indeed, it is possible that ecological monitoring and pest management programs may reduce the incidence of this KTP in the Study Area.

Herbivory and environmental degradation caused by feral deer: Six species of deer have established feral populations in New South Wales. Of these, the rusa deer (*Cervus timorensis*) was recorded within the Study Area.

Feral deer have recently been identified as the most important emerging pest animal threat in NSW. Impacts on native flora and fauna include overgrazing, browsing, trampling, ring-barking, antler rubbing, dispersal of weeds, creation of trails, concentration of nutrients, exposing soils to erosion/accelerating erosion, and the subsequent degradation of water quality in creek and river systems.

It is unlikely that any activities associated with the Anvil Hill Project will cause an increase in the incidence of this KTP within the Study Area, or locality in general. Indeed, it is possible that ecological monitoring and pest management programs may reduce the incidence of this KTP in the Study Area.

Human-caused climate change: A detailed greenhouse gas and energy assessment for the Anvil Hill project has been undertaken by independent specialists (SEE Sustainability). This has included an assessment of the energy and greenhouse gas emissions from the Project in accordance with recognised assessment guidelines, calculation of energy consumption and greenhouse gas emissions for various operational scenarios, and identification of relevant management controls that can be utilised to minimise energy use and greenhouse gas emissions.

The average annual greenhouse emissions for the Project are estimated at 167,574 tonnes CO2 equivalent (TCO2e). The greenhouse index of 0.031 TCO2e per tonne of saleable coal is less than the Australian open cut black coal mining industry average of 0.05 TCO2e/tonne (AGSO, 2000).

The estimated energy usage for the Project is dominated by diesel usage with the remaining consisting of electrical energy. The energy index of 0.226 GJ per tonne of saleable coal is less than the Australian open cut black coal mining industry average of 0.29 GJ/tonne. (AGSO, 2000)

The results of the assessment indicate that the Project is expected to result in a greenhouse index and energy index of lower than the open cut black coal mining industry average, suggesting that (on an industry wide basis) the Project is not expected to make a significant contribution to the incidence of the human-caused climate change KTP.

Importation of red imported fire ants into NSW: Red imported fire ants have recently been discovered at two separate foci in Brisbane, Queensland. The principal means of transport of queens is in soil and landscaping products such as mulch, old timber rails and pot plants.

Foraging red imported fire ants damage plants by eating fruit, seeds, tunnelling into stems and girdling seedlings. They also prey heavily on ground invertebrates and attack any slow moving vertebrates such as bird nestlings. People, stock and domestic pets are readily stung if they disturb a nest and this can induce anaphylactic shock in sensitive individuals (Vinson 1997). Studies have shown reductions in biodiversity in areas containing this species.

It is unlikely that any activities associated with the Anvil Hill Project will cause an increase in the incidence of this KTP within the Study Area, or locality in general.

Infection by Psittacine circoviral (beak and feather) disease affecting endangered psittacine species and populations: Psittacine Circoviral (beak and feather) Disease (PCD) affects parrots and their allies (psittacines) and is often fatal. It has been identified in more than 38 species of captive and wild indigenous psittacine birds in Australia, however all psittacine species are considered susceptible to infection. In circumstances where bird populations have been dramatically reduced, such as in an endangered species, the disease has the potential to cause catastrophic losses.

Psittacine Circoviral (beak and feather) Disease affecting endangered psittacine species is listed under the *Environment Protection and Biodiversity Conservation Act* 1999 as a Key Threatening Process.

It is unlikely that any activities associated with the Anvil Hill Project will cause an increase in the incidence of this KTP within the Study Area, or locality in general.

Infection of frogs by amphibian chytrid causing the disease chytridiomycosis: Chytridiomycosis is a fatal disease of amphibians and is caused by the chytrid *Batrachochytrium dendrobatidis*. Chytridiomycosis is a global epidemic, and has been recorded from a number of broad geographic regions in Australia. The spread of the disease is attributed to transport of frogs, as part of the pet trade, or accidentally with agricultural produce. Collection and handling of frogs and inadvertent transport of infected material between frog habitats may also promote the disease's spread. Chytridiomycosis is potentially fatal to all native species of amphibian, although stream-associated frog species are more likely to be infected because the pathogen is waterborne. No evidence of the presence of this pathogen was recorded during surveys of the Study Area.

It is unlikely that any activities associated with the Anvil Hill Project will cause an increase in the incidence of this KTP within the Study Area, or locality in general. All amphibian surveys have employed appropriate hygiene and handling protocols, particularly when moving between waterbodies.

Infection of native plants by *Phytophthora cinnamomi*: *Phytophthora cinnamomi* is a soil borne pathogen, which infects vegetative mycelia in soil and plant roots in warm, moist conditions. The spread of this pathogen occurs through movement of spores in flowing water, by mycelial growth from infected roots to healthy plants, or by movement of infected soil and/or root material. *Phytophthora cinnamomi* infects a large range of species. Some are killed, some are damaged but endure, and some show no apparent symptoms. This threat results in the death of plants and reduction in habitat complexity.

'Dieback caused by the root-rot fungus (*Phytophthora cinnamomi*)' is listed as a key threatening process under the *Environmental Protection and Biodiversity Conservation Act* 1999).

It is unlikely that any activities associated with the Anvil Hill Project will cause an increase in the incidence of this KTP within the Study Area, or locality in general.

Introduction of the large earth bumblebee, *Bombus terrestris*: At present this species is not known to occur in NSW, but could establish through accidental introduction from colonies in Tasmania and New Zealand. Large Earth Bumblebees are specialist pollinators of a number of European plant species, and this may facilitate an increase in the abundance and distribution of weed species, particularly species such as Scotch Broom (*Cytisus scoparius*). The presence of the Large Earth Bumblebee may also disrupt pollination of native plant species (Hingston and McQuillan 1998).

It is unlikely that any activities associated with the Anvil Hill Project will cause an increase in the unwitting importation of this species into the Study Area.

Invasion of native plant communities by bitou bush and boneseed: *Chrysanthemoides monilifera* is a South African species with two Australian subspecies - ssp. *monilifera* - boneseed, and ssp. *rotundata* - bitou bush. Vigorous growth, prolific seed production and effective seed dispersal of both subspecies enable them to compete strongly with, or in some places eliminate, native vegetation. The ability of *Chrysanthemoides monilifera* to become the overwhelming dominant in invaded ecological communities threatens all communities within the area of potential distribution of both subspecies of *Chrysanthemoides monilifera*.

It is unlikely that any activities associated with the Anvil Hill Project will cause an increase in the incidence of this KTP within the Study Area, or locality in general. Indeed, it is likely that ecological monitoring of remnant vegetation, and management actions such as weeding and revegetation will reduce the incidence of this KTP in the Study Area.

Invasion of native plant communities by exotic perennial grasses: A number of exotic perennial grasses invade and may dominate native plant communities. The characteristics of vigorous growth, prolific seed production and effective seed dispersal enable many exotic perennial grasses to compete strongly with, or in some places displace, native vegetation. The changed structure and fire regimes of the habitat are likely to adversely impact on both native vertebrate and invertebrate fauna. This may result in local and regional declines of many native species and communities, possibly to the extent that they become endangered. Many of the perennial exotic grasses establish following disturbances such as overgrazing, road works and management of roadside areas. Spread of these grasses is often aided by slashing, weed control, forestry and mining operations, movement or addition of fertilisers and nutrients, changes to drainage and fire regimes.

The Study Area already contains moderate to high levels of exotic perennial grasses, thus this KTP is already operating within the Study Area. The Anvil Hill Project may increase the prevalence of these species within the Study Area, particularly due to disturbances due to earthworks. Despite this, it is likely that ecological monitoring of remnant vegetation, and management actions such as weeding and revegetation will control and manage the incidence of this KTP in the Study Area.

Invasion of the yellow crazy ant: The Yellow Crazy Ant is a scavenging predator with a broad diet. It preys on a variety of litter and canopy fauna, from small isopods, myriapods, earthworms, molluscs, arachnids, and insects to large land crabs, birds, mammals, and reptiles. It is capable of invading both disturbed and undisturbed tropical and subtropical habitats, including urban areas, rural villages, plantations, coastal strand, grassland, savanna, woodland, and rainforest (O'Dowd et al. 2003). The Yellow Crazy Ant poses a significant threat to biodiversity as the ants have the potential to displace native fauna.

It is unlikely that any activities associated with the Anvil Hill Project will cause an increase in the incidence of this KTP within the Study Area, or locality in general.

Loss and/or degradation of sites used for hill-topping by butterflies: Hill-topping in butterflies is a very complex behaviour that often facilitates meeting of the sexes, usually as a focus for mating. Many butterfly species appear to be obligatory hill-toppers and tend to congregate on hill or ridge tops that are usually higher than the surrounding countryside. The same sites are used year after year. Small changes in the appearance of a site can result in males not recognising it as a suitable site. In the absence of other hill-topping sites, butterflies may disappear entirely from a district.

It is unlikely that any activities associated with the Anvil Hill Project will cause an increase in the incidence of this KTP within the Study Area, or locality in general.

Predation by feral cats: This species has been recorded across the Study Area and is likely to occur throughout the locality. Its presence is likely to be impacting on the biodiversity within the Study Area, and locality in general.

Cats occur in virtually all terrestrial habitats in Australia, and the main determinants of local population size appear to be the availability of food and shelters. The feral cat is carnivorous and capable of killing vertebrates up to 2-3 kg. Preference is shown for mammals weighing less that 220 g and birds less than 200 g, but reptiles, amphibians and invertebrates are also eaten. This species has the potential to cause a number of additional native species to become threatened. Predation by feral cats has been implicated in the extinction and decline of many species of mammals and birds on islands around Australia and in other parts of the world, and in the early extinction of up to seven species of small mammals on the Australian mainland.

It is unlikely that any activities associated with the Anvil Hill Project will cause an increase in the incidence of this KTP within the Study Area, or locality in general. Indeed, it is possible that ecological monitoring and pest management programs may reduce the incidence of this KTP in the Study Area.

Predation by the European red fox: The European red fox (*Vulpes vulpes*) was recorded within the Study Area during detailed seasonal surveys. This species is likely to occur throughout the locality, and this presence is likely to be impacting on the biodiversity within the Study Area, and locality in general.

The European red fox is an adaptable and elusive predator common in rural and urban areas throughout southern. It is predominantly carnivorous, and is largely opportunistic in its selection of prey. It has been identified as a vector of a number of weed species. Predation by the fox is a major threat to the survival of native fauna, with non-flying mammals weighing between 35 g and 5 500 g and ground-nesting birds at greatest risk. Reptiles, amphibians and invertebrates are also preyed upon by the fox. Even at low densities foxes can eliminate remnant populations and jeopardise species recovery programs.

It is unlikely that any activities associated with the Anvil Hill Project will cause an increase in the incidence of this KTP within the Study Area, or locality in general. Indeed, it is possible that ecological monitoring and pest management programs may reduce the incidence of this KTP in the Study Area.

Predation by the plague minnow (*Gambusia holbrooki*): *Gambusia holbrooki* is a small freshwater fish originally introduced into Australia in the 1920s. It is an aggressive and voracious predator, having an impact on fish, invertebrates and frogs. The presence of *Gambusia holbrooki* has been linked to the decline of a number of frog species in localized waterways, particularly of *Litoria aurea.* Breeding by *Litoria aurea* is almost completely restricted to water bodies lacking *Gambusia holbrooki.*

This species was recorded within Big Flat Creek, Sandy Creek and Wybong Creek as part of the aquatic surveys. As the species is currently present within the Proposed Disturbance Area and Proposed Offset Area, the aquatic fauna species of these areas are already likely to be impacted by this introduced predator. It is unlikely that any activities associated with the Anvil Hill Project will cause an increase in the incidence of this KTP within the Study Area, or locality in general. Indeed, it is possible that ecological monitoring and pest management programs may reduce the incidence of this KTP in the Study Area.

Removal of dead wood and dead trees: The accelerated and ongoing removal of standing dead trees and woody debris on the ground caused by human activity has been recognised as a factor contributing to loss of biological diversity. Examples of the process include illegal or poorly regulated firewood collection from forests and woodlands and unsustainable loss of fallen woody debris, which may be stacked, burnt, mulched or otherwise removed from the site. The removal of dead wood, either standing or fallen, can cause the broadscale change of woodlands into paddocks with isolated standing trees, with little natural understorey and no woody debris on the ground. In Australia about 290 vertebrate species use tree hollows, many on an obligate basis. Within NSW about 120 vertebrate species use tree hollows and most can utilise dead trees as nest sites. Dead standing trees in paddocks, resulting from clearing efforts or dieback, form a critical resource for fauna. The presence of standing dead trees and woody debris is an important component of the structure of forest and woodland and helps determine the habitat value for a wide range of fauna. Removal of dead wood and dead trees may seriously affect the long term availability and viability of habitat.

The Anvil Hill Project will require the removal of dead wood and dead trees from within the Proposed Disturbance Area. No removal of dead wood and dead trees will occur within the Proposed Offset Areas. Additionally, the proposed ameliorative measures will involve the placement of removed hollow logs, salvaged hollows and fallen timber into the Proposed Offset Areas as part of the habitat augmentation program. A detailed nest box strategy was also included within the Project in order to address the loss of hollows and mature trees from the Proposed Disturbance Area.

While the Project will result in an increase in the incidence of this KTP within the Proposed Disturbance Area, this will be ameliorated by the salvage and repositioning of such habitat, as well as the use of nest boxes.

Critical Habitat

Will critical habitat be affected?

There are currently four listings on the Critical Habitat Register, these being:

- Bomaderry zieria within the Bomaderry bushland - critical habitat recommendation;
- *Wollemia nobilis* (the Wollemi pine) - critical habitat recommendation;
- Little penguin population in Sydney's North Harbour - critical habitat declaration; and

- Mitchell's Rainforest Snail in Stotts Island Nature Reserve - critical habitat declaration.

While parts of the northern borders of Wollemi National Park lie approximately 20 kilometres to the south of the Study Area, the Anvil Hill Project will not pose a potential impact on the areas recommended for declaration as critical habitat for the Wollemi Pine (*Wollemia nobilis*).

The Anvil Hill Project will not impact on any other areas of declared critical habitat.

Part B of the Anvil Hill Project Ecological Assessment is located in Volume 5 of the Environmental Assessment

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